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DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1987

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

ON THE

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

MARCH 17, APRIL 29, MAY 5, AND JUNE 23, 1986

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DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1987

(Conservation and Renewable Energy and Fossil Energy)

MONDAY, MARCH 17, 1986

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:10 p.m., in room SD-366, Dirksen Senate Office Building, Hon. Pete V. Domenici, presiding.

Present: Senators Domenici, Hecht, Evans, and Ford.

Also present: Marilyn Meigs, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

Senator DOMENICI. The subcommittee will come to order. Thank you for being here, Senator, and we will try to expedite the hearing.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator DOMENICI. Although the Department of Energy budget is nearly unchanged, $12.1 billion in fiscal year 1987 compared to $11.97 in fiscal year 1986, about a 1-percent increase over 1986, it seems that the programs supporting fossil fuel, solar and renewable energy and conservation are taking a substantial reduction, anywhere from 47 to 58 percent.

Many believe that the priority of the proposed budget is shortsighted and does not reflect the priorities that Congress desires or that are good for the country. I understand we are under severe fiscal restraint, and clearly the office will try to have some balance in the energy programs.

The R&D policy is one that should be within the limits of our foresight and should insure some stability in reducing dependence on foreign energy sources and should not be oscillating as much as the world oil prices which are out of our control. Cost effective R&D is essential. Ultimately it has the chance to provide us with adequate technologies, hopefully when we need them.

Today our purpose is to take testimony in the hope that Congress and the administration, as we move through the year, can come up

with some changes in priorities that were in the President's budget so we will have a more balanced R&D program.

[A prepared statement submitted for the record by Senator Bingaman follows:]

STATEMENT BY SENATOR JEFF BINGAMAN
Department of Energy Fiscal Year 1987 Budget
Conservation, Renewable and Fossil Energy Programs
March 17, 1986

I thank Senator Domenici and Senator Ford for holding this hearing to review the proposed budget for Conservation, Renewable, and Fossil Energy programs within the Department of Energy. The Administration has been trying for almost six years to decimate the worthwhile federal energy research and development initiatives in these areas. I have opposed this short-sighted policy in the past and will do so more vigorously now and in the future.

It seems to me to be another example of the Administration's misplaced priorities. The magnitude of the cuts in the President's proposed budget are particularly unwise as we face a very uncertain energy future. The recent rapid decline in oil prices will inevitably mean greater dependence on imported crude oil and petroleum products and the displacement of domestic supplies. We see the continuing reduction in capital expenditures by the major oil companies in exploration and development activities and the permanent loss of low volume stripper wells by many of our own independents. Further, the volatility of the Middle East

situation could easily lead to a disruption in supplies that we are no longer able to respond to effectively.

Knowing the uncertainty of our energy future should make us even more determined in our resolve to achieve energy independence.

We can only attain this goal with aggressive government support for conservation and renewable technologies such as solar, geothermal and hydropower. We also need to preserve the tax credits that have made the application of these technologies more available in the marketplace. Finally, we need to continue our efforts to extend our supplies of fossil fuels.

These important programs require and deserve the federal government's support. The proposed 52 percent cut in Conservation and Renewable programs and the 73 percent cut in Fossil programs cannot be justified. I cannot support this budget.

New Mexico Impacts

The proposed budget has a tremendous impact on the work performed by the national laboratories in New Mexico in alternative energy research. At Sandia National Laboratory, major efforts have been discontinued. Funding for Solar and Geothermal research is reduced by this budget by about 25%

from last year and could result in a 50% reduction in contractor support and outside research activities. Funding for enhanced gas recovery may decline substantially, and efforts in coal related research will be reduced 50%. At Los Alamos National Laboratory, there will be insufficient funds to complete the Hot Dry Rock geothermal energy program, which has seen significant accomplishments over the last three years. Besides the laboratories, funding to state government for conservation programs will be cut substantially - affecting many New Mexicans who have come to depend on these conservation initiatives. The Department has also requested the deferral of $450,000 for the operation of the Residential Energy Program at New Mexico State University after Congress appropriated the money last year. The program carries out worthwhile photovoltaics research and provides employment for approximately 20 individuals.

This committee has already expressed its opposition to the proposed budget and its support for maintaining these programs at the FY '86 appropriated levels. I hope the Administration will finally understand that we do not find it in the best interest of the country to abandon the pursuit of energy independence.

Senator DOMENICI. Senator Ford, did you desire to make an opening statement?

Senator FORD. Mr. Chairman, I have no opening statement. I might say that Senator Rockefeller was unavoidably detained, and he reserves the right to send questions in writing to the witnesses today.

Senator DOMENICI. Thank you very much. We will submit them and hope they will be responded to.

The first witness is Hon. Claudine Schneider, U.S. House of Representatives. We are delighted to see you. We have seen your prepared remarks. You are at liberty to state them in detail or summarize them, whichever you prefer.

STATEMENT OF HON. CLAUDINE SCHNEIDER, A U.S. REPRESENTATIVE FROM THE STATE OF RHODE ISLAND

Ms. SCHNEIDER. Mr. Chairman, thank you for the opportunity to speak to the subcommittee this afternoon regarding the Department of Energy's fiscal year 1987 conservation budget.

As a member of the House Subcommittee on Energy Development and Applications, which authorizes DOE's conservation budget, I am very disturbed by the proposals to eliminate two-thirds of the energy-efficient R&D programs and to completely eliminate the State and local energy conservation programs.

These proposals come fast on the expiration of the conservation tax credits. I think it is important to look at this in the big picture, but I think this means that out of the roughly $40 to $50 billion per year that we spend on Federal tax and budget energy subsidies, that energy efficiency will receive a mere $70 million out of a total of $50 billion. Clearly, the Federal Government is distorting the marketplace by making such changes.

These actions are not at all consistent with DOE's national energy policy plan that calls for efficiency as the cornerstone of Federal energy policy.

As you know, energy efficiency right now provides one-fifth of U.S. energy services. It saved the American economy about $150 billion in the last year. These efficiency measures have also displaced the equivalent of about 13 million barrels of oil per day, and I believe that that is the key reason that we have seen the collapse of OPEC's power and world oil prices.

If we had not had these efficiency improvements, then what? Well, I think we would be guaranteed that we would be importing four times as much oil as we do now. Oil prices would still be very high. OPEC would still be in control, inflation rates would be high, and the trade deficit would be even more horrendous than it is, not to mention the fact that the United States and its allies would be extremely vulnerable to any Mideast oil disruption.

In light of the energy efficiency's incredible success in improving economic productivity and enhancing national security, it is hard to figure out why DOE's zealous budget-cutting efforts have been targeted toward these projects. I think this Nation has run out of energy; there is no reason to believe that we have run out of energy-efficient opportunities. The United States continues to con-

sumes as much as 75 percent more energy per unit of GNP than our foreign competitors such as Japan and France.

Just about 20 minutes ago, I had the opportunity to speak at the Brookings Institute and to share with them some of the specifics as to how competition with Japan and our other allies is being severely damaged through our failure to invest in energy-efficiency improvements and keeping apace with the high technology opportunities for international competition.

According to the analysis, cost-effective efficiency investments could trim an additional $150 billion a year off of our annual energy budget. The oil price hikes in the 1970's spawned our fuel-saving efficiency improvements. Now in the 1980's, we have solid state electronic advancements that are spawning another enormous pool of electricity savings that deliver services at 2 to 10 times cheaper than building new powerplants, not to mention the capital that is required in building new powerplants.

The savings in U.S. manufacturing and industrial facilities for electricity represent 40 percent of their electricity consumption. This can be significant, particularly to the Northeast/Midwest region of the country, where we still see a great deal of energy consumption in the manufacturing and industrial sector.

I would like to ask, Mr. Chairman, to have submitted into the record a copy of the report by the American Council for Energy-Efficiency Economy. That report points out that the United States is receding from Federal support for energy efficiency R&D while our foreign trade competitors are maintaining or increasing their R&D efforts. Right now, the United States ranks fifth in the funding levels behind the United Kingdom, France, Japan, and Germany.

The other thing I would mention is that the President's Commission on Industrial Competitiveness has also noted that the United States has lost not only a large market share in the auto, steel, rubber and primary metals industries, but we have also lost shares in 7 out of the 10 high technology markets—and energy efficiency products are among those fast-growing high technology markets.

One electricity-consuming product after another is being totally renovated with high technology design improvements in solid state electronic devices. Japan, which is the leader, is about to extend its assault on the United States manufacturers of motors, lighting systems, heat pumps, air conditioners, photovoltaics, and industrial processes.

And just as Japan has captured a major segment of the United States auto market with high efficiency models, their emergence into the high energy efficiency consuming products is also on the upswing. In order to protect the U.S. domestic markets and to improve our global competitive position, I think we should be pursuing national energy policies that help to cut in half the 12 percent of our GNP that pays for energy, not to mention the impact that this would have on a lower budget deficit.

So although the U.S. energy sector accounts for about 12 percent of the GNP, it represents 40 percent of the total investment in plant and equipment expenditures.

The final point I would like to make about the oil price collapse is one of national security. There is no assurance that our oil price

collapse will sustain itself. The U.S. Energy Information Administration has projected that substantial increases in oil imports in the 1990's will occur as a result of declining U.S. oil reserves.

As a matter of fact, it is worthy of note that between 1979 and 1984 the U.S. oil industry invested $250 billion in oil exploration alone without achieving a net increase in U.S. reserves at the end of 5 years, if we could just imagine what benefits we could have reaped if that $250 billion had been invested in energy-efficiency improvements.

So, Mr. Chairman, I would like to urge you and the members of the committee to please strongly support the freeze of DOE's conservation programs at the 1986 level. I think the fact that they have suffered a 50-percent cut over the past 5 years is contributing more than their share to balancing the budget.

I would also like to point out that I would certainly appreciate your support for the least-cost energy planning initiative, which is part of the energy conservation budget. This is a 3-year, $4 million technology transfer program that I initiated as a member of the Science and Technology Committee. It is a modest program that has broad-based support from the National Association of Regulatory Utility Commissioners, the American Gas Association, the American Public Power Association, the Edison Electric Institute, and the National Association of State Utility Consumer Advocates.

Essentially what it would do would be to return the benefits of taxpayer funded research to the U.S. utilities and to the ratepayers. The essence of the technology transfer program is to provide information on a full range of energy efficiency technologies to the utilities and also new, innovative schemes on energy management.

So I am hopeful that this committee will be receptive to the concept of developing a balanced approach to our energy policy and recognizing that we cannot afford to put all of our eggs in one basket and that diversity is a way of securing not only a lasting energy supply but also a more secure energy supply.

Thank you, Mr. Chairman.

[The prepared statement of Ms. Schneider follows:]

STATEMENT OF REP. CLAUDINE SCHNEIDER

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

SENATE COMMITTTEE ON ENERGY AND NATURAL RESOURCES

REGARDING THE DEPARTMENT OF ENERGY'S

FY87 CONSERVATION BUDGET

March 17, 1986

Mr. Chairman, Thank you for the opportunity to speak to the Subcommittee this afternoon regarding the Department of Energy's Fiscal Year 1987 Conservation budget. As a member of the House Subcommittee on Energy Development and Applications, which authorizes DOE's conservation budget, I am deeply disturbed by DOE's proposal to eliminate two-thirds of federal energy efficiency R&D programs, and completely eliminate the state and local energy conservation programs.

These proposals came fast upon the expiration of the conservation tax credits. This means that out of the roughly $40 to $50 billion per year in federal tax and budget energy subsidies, energy efficiency will receive a mere $70 million. Clearly the federal government is distorting the marketplace. Such actions are not consistent with DOE's National Energy Policy Plan that calls for efficiency as a cornerstone of federal energy policy.

As you may know, energy efficiency now provides one-fifth of U.S. energy services (based on improvements since the 1973 Arab oil embargo). These investments in raising the efficiency of millions of buildings, vehicles, appliances, commercial equipment and manufacturing processes have saved the American economy $150 billion per years in energy savings by requiring 25% less energy to produce a dollar of Gross National Product.

Efficiency measures have also displaced the equivalent of 13 million barrels of oil per day -- three times today's foreign oil imports. They are the key reason for the collapse of OPEC's power and world oil prices. If we hadn't had these energy efficiency improvements, then what? Well, the U.S. would be importing four times as much oil as it does; oil prices would still be very high, OPEC would still be in control, inflation rates would be high, the trade deficit would be horrendous, and the U.S. and its allies would be extremely vulnerable to any Mid-East oil disruption.

In light of efficiency's incredible success in improving economic productivity and enhancing national security it is hard to fathom DOE's zealous budget cutting of these programs in a proposed budget that increases $600 million to $12.8 billion!

Clearly it is not because this nation has run out of efficiency investment opportunities. The U.S. continues to consume as much as 75% more energy per unit of GNP than foreign competitors such as Japan and France. According to both government and independent analyses, cost-effective efficiency investments could trim an additional $150 billion per year off of

the nation's nearly half trillion dollar annual energy bill.

This proves to be the case in spite of the collapse in world oil prices. Most notably because oil prices are largely decoupled from electricity prices. As the attached chart shows, oil fuel expenses represent only 2.7% of the total price of electricity. Non-fuel expenses, mainly capital, constitute fully 75% of the price of electricity. Even if the average cost of oil to utilities were to drop 50%, the average retail price per kilowatt-hour would decline by only about 1/10th of a cent. The savings are insignificant in comparison to the rate shock caused by electricity prices from newly completed nuclear powerplants coming in at two to four times today's national average price of 7¢/kwh.

It's important to recognize that the oil price hikes in the 1970s primarily spawned fuel-saving efficiency improvements. Now, in the 1980s, we are witnessing solid state electronic advancements spawning an enormous pool of electricity-saving opportunities that "deliver" electricity services at two to ten times cheaper than building powerplants.

Take U.S. buildings, for example, which consume $100 billion per year in electricity--representing three-fourths of electric industry revenues. Efficiency investments with relatively fast paybacks can save $50 billion of that sum. Comparable percentage savings are available in U.S. manufacturing and industrial facilities, where electricity represents 40% of their total energy consumption.

Some of these savings will be secured as a result of past federal energy efficiency R&D programs. According to a recent report by the American Council for an Energy Efficient Economy and the Energy Conservation Coalition, the taxpayers have been handsomely rewarded for their investment in this research. In seven case studies, $16 million of R&D will save U.S. consumers $68 billion over the next 25 years.

The report also points out that the U.S. is receding from federal support for energy efficiency R&D while our foreign trade competitors are maintaining or increasing their R&D efforts. The U.S. ranks fifth in funding levels behind the U.K., France, Japan and Germany. Mr. Chairman I would like to request that the ACEEE report be submitted in the record along with my written testimony.

This failure to maintain adequate federal funding for efficiency R&D is a very serious problem. As the President's Commission on Industrial Competitiveness noted in its 1985 report, Global Competition: The New Reality, the U.S. has lost not only large market shares in the auto, steel, rubber and primary metal industries, but has also lost shares in seven of the 10 high technology markets; and energy efficiency products are among these fast-growing high technology markets.

One electricity-consuming product after another is being totally renovated with high technology design improvements and solid state electronic devices. Japan, the leader, is about to extend its assault on U.S. manufacturers of motors, lighting systems, heat pumps, air conditioners, photovoltaics, and

industrial processes, just as Japan captured a major segment of the U.S. auto market with high efficiency models.

To protect U.S. domestic markets and improve our global competitive position, we should be pursuing national energy policies that help to cut in half the 12% of GNP that pays for energy.

Federal energy efficiency R&D also contributes to underlying policy goals of a lower budget deficit. A burgeoning natonal debt means higher interest rates, which threaten to stifle economic growth by competing with the private sector for available capital.

But the federal deficit is not the only drain on investment capital. Although the U.S. energy sector accounts for about 12% of GNP, it represented 40% of total investment in plant and equipment expenditures, for all sectors, in 1982. Increased efficiency, several times cheaper than traditional supply, can make a significant contribution to the objective of increased capital availability and lower inflation rates that are underlying goals of the Gramm-Rudman legislation.

Hundreds of billions of dollars of capital would be freed-up for spurring non-energy business expansion and job creation, and for repairing America's deteriorating infrastructure of bridges, roads, sewers and waterlines.

The second point to be made about the oil price collapse is one of national security importance. There is no assurance the oil price collapse will sustain itself. The U.S. Energy

Information Administration projects substantial increases in oil imports in the 1990s as a result of declining U.S. oil reserves.

It is noteworthy that between 1979 and 1984 the U.S. oil industry invested $250 billion in oil exploration alone, without achieving a net increase in U.S. reserves at the end of the five years. Imagine what benefits we could have reaped if that $250 billion had been invested in energy efficiency measures.

Because OPEC controls two-thirds of the world's cheap oil reserves, in the absence of further fuel-saving efficiency improvements we will be back to a very vulnerable situation in the 1990s with high levels of foreign imports.

Obviously the cheapest insurance against such a crisis is to encourage cost-effective efficiency investments. This includes overcoming a variety of technical and informational barriers to greater efficiency use through the continuation of a modestly funded federal energy efficiency R&D program and state and local assistance programs.

As such, Mr. Chairman, I urge you and the committee to strongly support a freeze of DOE's conservation programs at the 1986 levels. These programs have already suffered a 50% reduction over the past five years, contributing more than their fair share to balance the budget. To reduce them further is to undermine their effectiveness and jeodpardize the energy savings that can continue to strengthen national security and enhance economic productivity.

I would especially appreciate your support for the Least-Cost Energy Planning Initiative within the conservation budget. This is a three-year, $4 million technology transfer program authorized by the House Science and Technology Committee last year.

This modest program, which has broad-based support from the National Association of Regulatory Utility Commissioners, the American Gas Association, the American Public Power Association, the Edison Electric Institute, and the National Association of State Utility Consumer Advocates, would return the benefits of taxpayer-funded research to U.S. utilities and ratepayers.

The essence of the technology transfer program is to provide information on the full range of energy efficiency technologies to utilities.

That concludes my testimony, thank you very much.

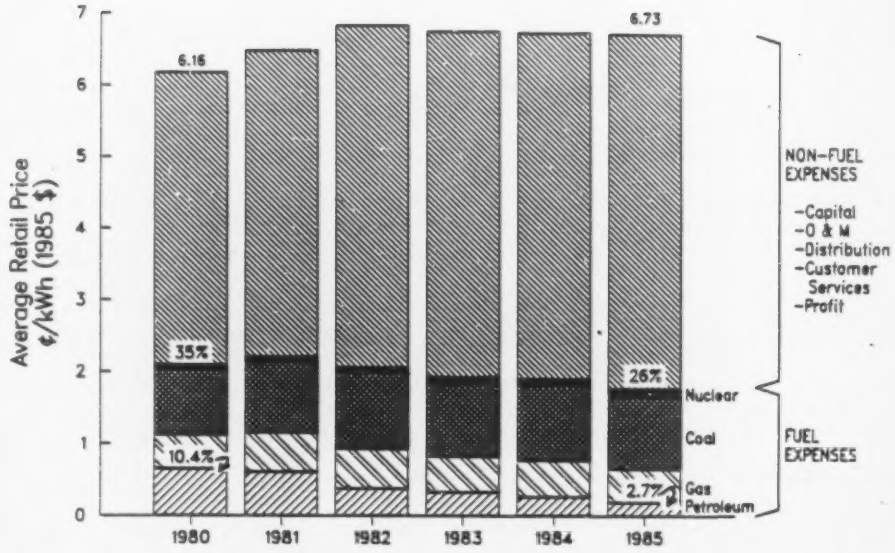

Figure 2. Fuel expenses as a component of the average U.S. retail price of electricity (in constant 1985 $), 1980 to 1985. Note that in real dollars, the average electricity price per kilowatt-hour (to all sectors) has changed little in six years, while the fuel component has declined from 35 percent to 26 percent. Non-fuel expenses, especially capital costs of new powerplants, have offset lower fuel costs. Oil costs have dropped even more dramatically, from 10 percent in 1980 to less than 3 percent in 1985. Even if the average cost of oil to utilities were to drop 50 percent, the average retail price per kWh would decline by only about 1/10 of a cent. Other cost increases would quickly offset any such decline.

Senator DOMENICI. Thank you very much. The report that you asked us to make part of the record will be incorporated in the subcommittee files. We will not ask that it be typed up but rather just be incorporated as part of the hearing record.

Senator Ford, did you have any questions?

Senator FORD. I have no question of the gentlelady.

Senator DOMENICI. Senator Evans.

Senator EVANS. Mr. Chairman, just a comment rather than a question. I think the testimony is really self-evident. It follows very closely the results we found in the Pacific Northwest Regional Power Council's activities.

Certainly the concept of least-cost planning is such common sense we wonder why we even have to emphasize it, but we have not emphasized it very much in the past years. We have not done it comprehensively enough.

I am convinced, as is Representative Schneider, that we have the capacity through greater efficiencies to radically change, even from where we are now, radically change the usage of energy and energy efficiencies will get us a big piece of the distance we have to go to avoid getting once again back in the same position we were in the 1970's when we were held hostage by the OPEC nations.

Ms. SCHNEIDER. I think we recognize the ramifications on the trade situation, as I had mentioned in my testimony, but I was rather disappointed that this morning one of the gentlemen from the Brookings Institute asked the question, he said, "Well, have we not achieved all the energy savings we possibly can since the last energy crisis?"

I think it is significant to note that there are many studies that I have pointed out that we, yes, have achieved about $150 billion per year since the energy crisis, but we still have a potential to achieve an additional $150 billion in savings through energy efficiency moves.

Senator DOMENICI. Representative Schneider, I want to compliment you on your work in this area and assure you we will do all we can to maximize the balance that you suggest.

I really think things are changing so fast that we are not going to know the effects of what is going on for a long time. Basically the matter of price drop is going to have a very significant effect on alternate sources. There is no question about it.

I believe we have a national history of being rather shortsighted in these areas. While I am hopeful that we will not do it again, I have a sneaking, intuitive feeling that we will. Clearly, the price drop is good news overall for the economy. It will be reflected in some very good inflation reports, and it clearly will be a stimulus.

I am just worried about 5, 6, 7, 10 years from now when a period of something rather dramatic will happen, and we should continue on with the research, especially in those areas where we know it will have some very major effects and can work. We will do our very best.

Thank you very much for appearing and for your patience. I apologize for the delay in starting.

Ms. SCHNEIDER. No problem. Thank you.

Senator DOMENICI. Donna Fitzpatrick, Assistant Secretary for Conservation and Renewable Energy from the Department, and

Mr. Donald Bauer, Acting Assistant Secretary for Fossil Energy for the Department of Energy.

We will have both of you appear, and Secretary Fitzpatrick, we will put your statement and that of Secretary Bauer in the record in their entirety. You may proceed to summarize them for us.

STATEMENT OF DONNA R. FITZPATRICK, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY

Miss FITZPATRICK. Thank you, Mr. Chairman. I would like to summarize briefly.

Senator DOMENICI. Please.

Miss FITZPATRICK. I appreciate the opportunity to appear before this subcommittee today to discuss the fiscal year 1987 budget request for conservation and renewable energy research and development. The budget for these programs is consistent with the goals and objectives of national energy policy and is fully responsive to the administration and congressional goals of deficit reduction.

The administration's overall energy goal is to foster an adequate supply of energy at reasonable cost. Achieving this goal will require us to make full use of our Nation's vast natural resources and the daring and ingenuity of our citizens. Our approach includes supporting advances in energy conservation, as well as possible energy supply sources of the future such as renewable energy.

Deficit reduction is perhaps the preeminent domestic economic imperative today, and the Department fully recognizes that fact. For this reason we are doing all we can to concentrate increasingly scarce resources on those programs and projects that directly fulfill a responsibility of the Federal Government and truly require Federal assistance.

If we are to achieve our overriding goal of a deficit reduction, we have no choice but to concentrate these resources where they show promise of bringing the greatest benefits.

I would like to briefly summarize our budget request in each of the program areas in energy conservation. The fiscal year 1987 budget request for conservation research and development totals $71.2 million. Let me give you a few examples of the types of activities which will be undertaken.

In our buildings and community systems program we will continue investigations of ways to maintain acceptable indoor air quality in energy efficient buildings. These efforts include studies of radon entry and mitigation methods. In cooperation with industry, we will continue research to advance the technology supporting thermally activated heat pumps and advanced lighting, as well as continue the utility least-cost planning initiative.

The budget request for industrial programs will be used to continue research, including thin strip casting of steel, high temperature recouperators and heat pumps advanced sensors and process controls for direct thermal-to-electrical conversion, waste conversion, and advanced separation processes.

The transportation program includes continuation of the heavy duty adiabatic diesel project. Component evaluations of developed ceramic structures in a single-cylinder test cell will be continue[d],

and the actual design by industry of a baseline multicylinder adiabatic diesel system will be carried out.

The budget also includes the energy-related inventions program which was established to evaluate the technical merits of energy-related inventions submitted to DOE and to provide technical assistance and grants to further develop promising inventions.

In the multisector program we will complete experimentation and modeling of the joining of ceramics to ceramics and ceramics to metal, which is an important element in providing reliable ceramic engines. This will involve using new microwave heating techniques.

The budget request also provides for continued investigation of both theory and experiment to expand our understanding of the relationships between bonding and structure at the atomic level in selected materials problems related to conservation. One of the possible results of this work could be the development of new ultra-high temperature materials.

Our renewable energy programs are contributing to an important part of our Nation's energy supply mix. In fact, renewable energy-based resources from solar and thermal are presently accounting for a great deal of the energy consumed in the United States.

When the Federally supported renewable energy programs began in 1974, most of these technologies well in the conceptual stage, but today we have made significant advances in all of these technologies. Teams of scientists and engineers from Government laboratories, universities and industry have created a solid technology base and expertise and have a broad array of disciplines pertaining to renewable energy technologies.

In order to support this development, our program will continue to address a range of fundamental issues. These issues include basic materials-related work on the structural integrity of reflective surfaces, and conversion efficiency of photovoltaic materials: resolution of wind technology reliability and durability issues through advancement of underlying structural and aerodynamic theory; combustion research; and biological health effects and risks associated with exposure to high voltage electric and magnetic fields; and the feasibility of using magma energy as a geothermal energy source for power generation. The proposed budget for supporting renewable energy R&D totals $108 million.

Mr. Chairman, this budget request maintains program goals and will allow us to address the items of highest priority in research and development in the fields of energy conservation and renewable energy, thereby contributing to the accomplishment of our national goal of fostering an adequate supply of energy at reasonable costs. This is a budget which I believe seriously recognizes today's fiscal responsibilities as well as tomorrow's anticipated needs and will build on the foundation of energy stability and security that we, working together with the Congress, have laid in the last few years.

Mr. Chairman, we are pleased to have the advice we have received from the Congress and particularly the subcommittee and we thank you for the opportunity to appear today.

[The prepared statement of Miss Fitzpatrick follows:]

STATEMENT OF

DONNA R. FITZPATRICK

ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITEE ON ENERGY RESEARCH AND DEVELOPMENT

UNITED STATES SENATE

March 17, 1986

Mr. Chairman and Members of the Subcommittee:

I appreciate the opportunity to appear before you today to discuss the FY 1987 budget request for the Conservation and Renewable Energy programs of the Department of Energy. The budget for these programs is consistent with the goals and objectives of national energy policy and is fully responsive to the Administration and Congressional goals of deficit reduction.

The Administration's overall energy goal is to foster an adequate supply of energy at reasonable cost. We can achieve that goal through the combination of energy stability, energy security, and energy strength. Energy stability has been achieved over the past five years. Our energy security is growing stronger day by day. Our objective for the immediate future is to build this Nation's energy strength, making full use of its vast natural resources and the daring and ingenuity of its citizens. Our approach includes supporting advances in energy conservation as well as possible energy supply sources of the future such as renewable energy.

Deficit reduction is perhaps the preeminent domestic economic imperative today and the Department fully recognizes that fact. For this reason, we are doing all we can to concentrate increasingly scarce resources on those programs and projects that directly fulfill a responsibility of the Federal government and truly require Federal assistance. If we are to achieve our overriding goal of deficit reduction we cannot afford to continue to allocate scarce Federal resources to activities where the

rationale for continued Federal involvement is weak and where State and local organizations or private industry can and should take over responsibilities presently borne by the Federal government. Also, we cannot permit programs or projects to continue with Federal support unless they meet a high priority national need. We have no choice under the current and necessarily strict fiscal regimen but to concentrate scarce resources where they show promise of bringing the greatest benefits.

As we seek ways to gain the greatest benefit from our limited resources, we will investigate cooperative research and development ventures with private industry consortia. This approach to R&D funding has the potential to provide greater leverage of Federal funds and to assure that resources for applied R&D are focused on high priority areas where there is private commitment to follow through with promising technologies. It can also foster increased technology transfer by involving industry earlier in the R&D sequence. One of our early steps will be the publication of a general solicitation of industry interest in forming R&D ventures in the various conservation and renewable energy program areas.

In order to contribute to the achievement of our goals, the FY 1987 budget request for energy conservation and renewable energy research and development (R&D) programs will continue to support development of a mix of technologies that can contribute to both energy supply and improved end-use efficiency. The FY 1987 budget request for Conservation and Renewable Energy programs under this subcommittee's jurisdiction totals

$179.3 million; $71.2 million for energy conservation programs, and $108.1 million for renewable energy R&D programs.

I would like now to discuss each of our major program areas under the Office of Conservation and Renewable Energy and its related FY 1987 funding request.

FY 1987 BUDGET REQUEST FOR ENERGY CONSERVATION R&D

The FY 1987 budget request for energy conservation research and development programs under this subcommittee's jurisdiction totals $68.8 million. It includes $11.9 million for Buildings and Community Systems, $15.6 million for Industrial Programs, $19.8 million for Transportation, $19.8 million for Multi-Sector Programs, and $1.7 million for Policy and Management.

Buildings and Community Systems

The buildings sector accounts for approximately 36 percent of our total national energy consumption. In residential buildings, space heating, water heating, and refrigeration use the largest amounts of energy; in commercial buildings, space heating, lighting, and air conditioning use the largest amounts. Significant energy savings can be achieved by improving the efficiency of these and related building functions. Our Buildings and Community Systems program conducts research to establish a technology base upon which industry can build to make these savings possible and makes the results of that research available to the private

sector. This program also implements mandated building energy regulatory programs. We are requesting $14.1 million for these research, technology transfer, and regulatory activities in FY 1987.

Of the funds requested, $11.9 million are for activities under the purview of this committee; $9.5 million for research and development projects and $2.4 million for program direction. The research and development funds are for three subprograms: Building Systems, Technology and Consumer Products, and Analysis and Technology Transfer.

We are requesting $3.5 million for the Building Systems subprogram in FY 1987 to continue research in walls, roofs, and indoor air quality, infiltration, and ventilation. The wall research will include thermal testing of different types of walls, evaluation of wall thermal anomalies, evaluation of the influence of mass on energy use, and study of foundation designs and earth contact.

Our roof research focuses on improving the energy efficiency and durability of roofs. In FY 1987, research areas will include testing the thermal performance of high and low efficiency roofs under field conditions, developing diagnostic probes for quantitative measurements of moisture in roof systems, and developing a mathematical model to predict thermal performance of composite roofs.

In FY 1987, we will continue our investigations of ways to maintain acceptable air quality in energy efficient buildings. These efforts will include studies of radon entry and mitigation methods and of the

generation and distribution of biological aerosols. We will also continue development and evaluation of infiltration, ventilation, and air leakage measurement systems.

We are requesting $5.0 million for the Technology and Consumer Products subprogram in FY 1987. The purpose of this research is to provide technologies needed to develop more efficient building energy conversion processes and equipment. The greatest promise for significant energy savings in building equipment appears to be in the areas of thermally activated heat pumps and advanced lighting.

In thermally activated heat pumps, we will continue research to advance the technologies for engine-driven and absorption systems. In lighting equipment research, we will continue to investigate advanced light sources with emphasis on magnetically loaded lamps and electrodeless gigahertz lamp discharges. We will also continue to study the optimized integration of lighting system components into the total building.

The purposes of the Analysis and Technology Transfer subprogram are to provide the analytic tools and information needed for program planning and to ensure that research results and information on conservation in buildings are transferred to potential users. We are requesting $1.0 million for this subprogram. This funding will support centralized technology transfer activities, continued U.S. participation in International Energy Agency agreements, technology assessments, and policy and program analyses.

We are requesting $2.4 million for Program Direction. This funding will provide salaries, benefits, and travel for a staff of 45 FTE's to manage the Buildings and Community Systems program.

Industry

The FY 1987 budget request for the Industrial Programs is $15.6 million. These funds will be used to carry out work in four subprograms: Waste Energy Reduction, Industrial Process Efficiency, Industrial Cogeneration, and Implementation and Deployment. The goal of these activities is to encourage improved energy efficiency in industry, which accounts for approximataely 37 percent of total U.S. energy consumption. The Department's activities in the industrial area consist of a comprehensive program of carefully targeted technological research and development, combined with technology transfer and other implementation efforts. The R&D activities focus on selected high risk ventures which are not likely to be pursued by the private sector alone and most are carried out by private institutions operating under cost-shared contracts or cooperative agreements with the Department.

The Waste Energy Reduction subprogram supports research and development on improved combustion efficiency through oxygen enrichment, improved burner designs, and sophisticated combustion controls; waste heat recovery by development of industrial heat pumps, high temperature recuperators, and ceramic materials for heat exchangers; and research into waste materials utilization and CO_2 generation and recovery. In FY 1987, $6.3 million is requested for this subprogram.

The Industrial Process Efficiency subprogram includes laboratory testing of technology to produce steel sheet directly from molten metal; R&D for advanced sensors and control systems; advanced separation systems; and testing of electrode materials for process electrolysis. In FY 1987, $5.5 million is requested for this subprogram. These new technologies hold great promise to reduce the energy required in basic industrial processes.

The Industrial Cogeneration subprogram focuses on research for coal/water slurry-fired diesel cogeneration systems with high electrical to thermal output and direct conversion of thermal to electrical energy. In FY 1987, $1.5 million is requested in this area.

The Implementation and Deployment subprogram supports a number of activities for technology transfer. These include targeted workshops, seminars and technical symposia, and the development of written materials focusing on technologies developed with DOE assistance. Altogether, $500,000 is requested for this subprogram.

We are requesting $1.8 million for program direction to support 26 full-time equivalent positions to manage the Industry program.

These technologies, if successfully brought into production, can provide U.S. industry with important improvements in productivity and help regain technical leadership positions vital to our success in world markets.

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Transportation

The FY 1987 budget request for the Transportation program is $19.8 million to continue R&D in four subprograms: Vehicle Propulsion R&D; Alternative Fuels Utilization; Electric and Hybrid Vehicle R&D; and Advanced Materials Development. These activities focus on the transportation sector, which accounted for approximately 27 percent of total U.S. energy consumption and, more importantly, 61 percent of U.S. petroleum consumption, up from 51 percent in 1973. The objectives of the Transportation program are to contribute to improved energy efficiency and enhanced diversity of available end-use technologies. These programs provide the technology base necessary to support private sector efforts to develop technologies which are either more efficient or serve as alternatives to those based exclusively on petroleum.

In FY 1987, $6.5 million is requested for the Vehicle Propulsion subprogram which supports research and development of high efficiency and advanced heat engine technologies. This area includes R&D on the automotive gas turbine and the heavy duty adiabatic (uncooled, minimum friction) diesel engines. The goals for both the gas turbine and the adiabatic diesel projects are to establish proofs-of-concepts and develop advanced heat engine technologies which have at least a 30 percent improvement in fuel efficiency over comparable conventional engines, meet emissions, safety, and noise standards, have alternative fuels capability, and have competitive life-cycle costs. Funds will be used to initiate a follow-on gas turbine component development project and to continue component evaluations of developed ceramic structures in a single-cylinder adiabatic diesel engine test cell, as well as the actual design by industry of a baseline multi-cylinder adiabatic diesel system.

For the Alternative Fuels Utilization subprogram, $1.3 million is requested, which is designed to establish a utilization oriented data base for alternative fuels in both contemporary and advanced heat engines. These funds will be used to conduct performance investigations into the fundamental behavior of synthetic fuels in conventional and advanced single- and multi-cylinder engines; to develop test synthetic fuels for project activities and the scientific community; and to continue data collection and analysis of the methanol-fueled vehicle fleet operations.

The Electric and Hybrid Vehicle subprogram request is $4.1 million which supports R&D activities necessary to advance the technologies of batteries and propulsion systems for passenger car and commercial van or light truck applications. These funds will be used to continue the development and laboratory testing of experimental flow-through lead-acid, sodium-sulfur, and zinc-bromine battery systems for electric vehicle application and to continue the dual-shaft a.c. propulsion system, which includes the development and vehicle integration of nickel-iron battery technology.

For the Advanced Materials Development subprogram the request is $6.5 million. This area addresses the need to develop improved materials that can withstand the high temperatures and corrosive environments of high performance energy conversion systems and, in particular, advanced transportation engines. The funds will be used to establish an industrial ceramic technology base through research on materials and processing of monolithic silicon nitride and silicon carbide, oxide matrix and dispersion toughened composites, thermal and wear zirconia-based coatings, dynamic interfaces, data base and life prediction, and International Energy Agency standardization of ceramic materials and

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testing. No funds are being requested for the publication and distribution of the Gas Mileage Guide. DOE will submit a legislative initiative to remove the mandatory printing and distribution of the Guide. DOE will encourage the private sector (automotive publications and newspapers) to print the fuel economy information when it is released each new model year by the Environmental Protection Agency. The information contained in the Guide is available to consumers from these sources and each new car sticker is required to include mileage ratings and comparison data.

Finally, $1.4 million is requested for 22 full-time equivalent positions to provide direction and management for the transportation programs.

Multi-Sector

The Multi-Sector Program includes the Energy-Conversion and Utilization Technologies (ECUT) program, the Energy-Related Inventions Program, and the National Appropriate Technology Assistance Service (NATAS). The FY 1987 budget request for Multi-Sector includes $15.8 million for ECUT, $3.3 million for the Energy-Related Inventions Program, and $0.75 million for NATAS.

The Energy Conversion and Utilization Technologies research activities are oriented toward basic research and crosscutting R&D problems common to more than one energy consuming sector. They also provide predictive models and design tools useful to the private sector in achieving greater energy productivity. The requested funding will be used to conduct research in six subprogram areas: Combustion and Thermal Sciences, Materials, Biocatalysis,

Tribology, International Research Monitoring, and Conservation Program Analysis and Planning.

In FY 1987, $4.8 million is requested for Combustion and Thermal Sciences Subprogram. Combustion research provides analytical and measuring techniques needed to understand the thermochemical and related processes that take place in the combustion of fuels and in the conversion of the released thermal energy to work. The results of this research are used to develop efficient, clean, and reliable combustion systems and devices. Thermal Sciences research develops improved thermodynamic analytical capabilities and experimentally validated computerized data bases. These are needed to provide the technological base used to improve heat transfer processes, reduce heat transfer surface area requirements, and minimize vibration induced by fluid flow through heat exchangers. In FY 1987, research will proceed to develop advanced analysis techniques and to generate a technological data base for the physical sciences of thermodynamics and heat and mass transfer.

The $5.4 million requested for Materials research will be used to investigate and modify the characteristics of high-temperature materials and to further develop the materials-by-design concept. Certain materials such as Long-Range Ordered (LRO) Alloys and Intermetallic Compounds, both of which have highly ordered atomic structures, have great potential for improving the efficiency and performance of high temperature processes, but have not yet been utilized because of their characteristic brittleness. The $2.4 million requested for Biocatalysis research will be used to establish a technological data base for the development of new techniques to manufacture industrial and commercial chemicals using biological systems analogous to conventional processes in

chemical engineering. The $2.4 million requested for the Tribology subprogram will be used for research on lubricants, friction and wear to ceramics, and coatings on machine tools that reduce heat and last longer.

Other ECUT funding requested in the FY 1987 budget--$0.8 million-- will be used to assess the status of foreign technologies related to energy conservation and compare it with U.S. technologies, for supporting analyses and for updating the Conservation 5-year plan.

The FY 1987 budget requests $3.3 million for the Energy-Related Inventions Program. This Program was established to evaluate the technical merits of energy-related inventions submitted to DOE and to provide technical assistance and grants to further develop promising inventions. The National Bureau of Standards (NBS) conducts evaluations through its Office of Energy-Related Inventions. Promising inventions identified by NBS are directed to DOE for further assistance to investigate sources of private sector funding or direct support where private sector support is not available. From program inception in 1974 through 1985 approximately 22,000 energy saving inventions had been evaluated by NBS. Based on NBS recommendations, 224 inventions have been awarded grants totalling $16.1 million. Of these, 36 have entered the marketplace generating sales of approximately $110 million and creating more than 900 direct jobs.

In FY 1987, the $3.3 million requested will support the analysis of approximately 1000 proposed inventions, and financial support for approximately 22 of the most promising inventions. During FY 1987, DOE will continue to work one-on-one with inventors to provide business planning assistance, and will

conduct workshops which we have tested and found to be very helpful to inventors in dealing with the various and complicated aspects of commercialization.

Appropriate Technology

The Appropriate Technology Program was established to support the development and demonstration of small-scale energy technologies that were matched in scale and nature to local needs. Over 2,000 projects were supported, and almost 900 development projects were completed, to advance the state-of-the-art in Appropriate Technology. In FY 1983, Congress appropriated funds to establish the National Appropriate Technology Assistance Service, to disseminate information on the energy conservation technologies developed through this program and to give expert advice and guidance in using them effectively. NATAS was established in FY 1984, and to date has received over 6,000 requests for information and assistance. The FY 1986 Budget Request contains $0.75 million for NATAS, for the continuation of information and technical assistance to individuals and small businesses.

We are also requesting $0.5 million for program direction to support 8 full-time equivalent positions to manage the Multi-Sector program.

FY 1987 BUDGET REQUEST FOR RENEWABLE ENERGY

The availability of stable and secure sources of energy will continue to play an important role in sustaining a robust domestic economy. The Department's renewable energy programs reflect a continuing national commitment to

diversify U.S. sources of energy supply in a manner which fosters free market choices. Renewable energy can be an important part of the nation's energy supply mix and renewable technologies are already making important contributions to national, regional, and local energy requirements. These contributions are possible since the family of renewable energy technologies spans a wide range of resource and technical options at varying stages of maturity. Some technology and resource combinations have been providing substantial energy for many years, others are just beginning to enter the supply system, and some remain in research phases.

Renewable energy technical development overall has been paralleled by an increasing level of confidence in and commitment to these technologies by the private sector. The renewable industry has made significant progress in recent years to its development into the diverse group of many small businesses and sizable divisions of large companies that we see today. There has also been progress with respect to the other institutions concerned with renewable energy supply and use. States have become increasingly involved with promoting renewable energy use, while universities, research institutes, and utilities are promoting awareness and conducting programs to further advance our knowledge of renewable energy potential.

Within the current Federal budget limitations, it is the Department's objective and role to participate in the highest priority research to address the most critical technology base issues. The focus of such efforts will be on those technologies with the greatest long-term promise for contribution to the nation's energy supply mix. These efforts will emphasize precompetitive research critical to advancing technology while avoiding interference with the

extraordinary capacity of industry to develop specific commercial products and services. The Department will continue to encourage private sector participation and leadership and will seek input from industry and other institutions in the selection of projects which have the greatest relevance and potential.

The request for FY 1987 of $108.1 million will allow the Department to perform the activities that reflect the nation's commitment to continued development of renewable energy resources, thereby increasing the nation's energy supply options, and, subsequently, national energy security.

I would now like to address the funding requests for selected major programs.

Solar Buildings

Solar buildings technologies have continued to make inroads in housing and, to a lesser degree, in the commercial buildings sector. These technologies can presently supply up to 40% of the energy required to heat individual homes across the United States. There is increasing scientific evidence that such energy contributions could be doubled and extended to additional types of building requirements for energy supply by means of continued opportunity for technological innovations. The FY 1987 Solar Buildings Technology Program budget request of $4.7 million for operating expenses will provide industry with an essential technology base for developing the new materials, components, and technologies required to realize this potential.

Working closely with industry and university laboratories, the Solar Buildings Program is conducting long-term, cross-cutting research which the diverse sectors of the industry cannot support. The goal of these research activities is to increase the energy contribution of solar technologies to the point where 70% to 80% of space heating, hot water, cooling, and lighting requirements of various types of buildings could be supplied at costs that are competitive with conventional fuels.

The FY 1987 program in materials and components includes continued research on new optical and thermal switching films which control solar gain and thermal losses for windows and exterior building surfaces. Research on innovative collectors will increase their thermal efficiencies and reliability, decrease their cost, and expand the application of active solar technologies to cooling systems and other building energy requirements.

New phase change materials incorporated in such conventional building materials as wallboards will make it possible to store and use thermal energy provided by solar energy in all parts of the building. Advanced thermal transport concepts will enable energy to be transferred from the point of collection at the building exterior to any interior location, thereby improving the energy performance of solar building systems.

Systems research activities encompass both residential and non-residential building applications. Research on open cycle solar absorption and solar desiccant cooling technologies will be aimed at increasing their energy efficiencies, the key to achieving viable solar cooling applications. An important element of the FY 1987 systems research program is the development

of analytical tools to allow architects and engineers to predict system performance. Researchers will also continue to monitor, analyze, and evaluate the performance and reliability of solar building technology. Analysis techniques are being developed for integrating these solar technologies with conventional heating and cooling systems.

Photovoltaics

Photovoltaics (PV) is on its way to becoming a significant energy supply option. The partnership between DOE and industry has resulted to date in rising conversion efficiencies, increasing reliability, and lower costs, all of which have helped the technology to establish a strong foothold in the competitive energy market, with a broad range of viable applications. In FY 1987 the Photovoltaic Program, with a budget request of $19.6 million for operating expenses and $1.0 million for capital expenses, will seek to advance the basic understanding of technical issues associated with materials formation and physical phenomena of the PV cell.

Amorphous silicon is an attractive thin-film photovoltaic material which could establish PV technology as a broadly competitive electric power production option. U.S. research leads worldwide efforts in addressing the issues leading to the optimization of single junction submodules and the investigation of higher efficiency multijunction concepts. The efforts will lay the ground work for a viable industrial effort capable of achieving 10 percent efficiency single junction and 13 percent multiple junction large area submodules.

Polycrystalline thin films also represent promising candidates for meeting the major programmatic criteria relating to cell efficiency, material processing requirements, and performance stability. Progress has been made in the development of low cost deposition methods, and in cell efficiency. FY 1987 efforts will concentrate on defining the scientific and technological barriers to approaching theoretical efficiency and on the development of large area film fabrication concepts for the most promising of these materials.

As a result of DOE's program, single-crystal gallium arsenide and single-crystal silicon solar cells currently hold records for the most efficient photovoltaic conversion of sunlight to electricity. But the efficiency of such materials is inherently limited because not all incident sunlight can be utilized due to the frequency selectivity of the specific materials involved. To overcome this difficulty, researchers are exploring concepts that will include seeking improvements in selected single-junction cells as well as studying concepts to mechanically or optically couple cells or to fabricate, as one structure, two or more cells of different materials. The goal of this high priority effort in high efficiency concepts is to achieve 35% efficient small area cells for use by industry as part of its development effort.

The FY 1987 program will also maintain its unique capability for precise measurement of material and cell parameters. This work at SERI guides researchers throughout the U.S. in understanding and correlating observed physical phenomena. The program will also support other fundamental research in quarternary and ternary compounds, and promote basic material work at universities. Finally, the wealth of information gathered by the program from materials to systems during its ten years of research and development will be

used to assist industry in its efforts to bring photovoltaic technology to competitive maturity, domestically and internationally.

Solar Thermal Technology

The technology base for solar thermal technology has dramatically improved as a result of significant achievements within the last two years. These achievements include substantial system cost reductions and performance enhancement due to the research in advanced solar thermal components and subsystems which resulted, in part, from DOE's cooperative efforts with industry. At present, solar thermal technologies are capable of delivering electricity at 13¢/kWhe. However, solar thermal technology must be capable of 5¢/kWhe for electric power production and $9/MBtu for thermal energy in order to be competitive with a mix of other energy generating technologies. The FY 1987 program, with a budget request of $15.3 million for operating expenses, emphasizes activities which address the component and subsystem improvements/advances necessary to approach these objectives. Heliostat sizes have increased three- to four-fold, while costs have been reduced by 40% since Solar One (Barstow) became operational in 1982. The stretched membrane concept has the potential to further reduce the heliostat field and parabolic dish concentrator costs by another 50%. The FY 1987 research will continue the design and testing of these advanced concepts.

Central receivers using molten salt or sodium as heat transfer fluids would allow reductions in the size of advanced receivers and enable the development of low pressure receivers that are lighter in weight with lighter support structures. The new fluids can also be stored at high temperature and

low pressure for plant operation during long hours of reduced insolation. Research efforts in this area to-date have established the basis for reduced receiver and storage costs by 50%, improving both the overall plant cost and levelized energy costs of solar thermal systems. The development and testing of these advanced subsystems will continue through FY 1987. The Vanguard dish module has proven the high conversion efficiency of sunlight to electricity by achieving a 29% net (31% gross) system efficiency using a kinematic Stirling engine. Development of the free-piston Stirling engine concept, in cooperation with NASA, will continue in FY 1987. This engine has the potential to achieve the long-term goals of high reliability and performance at competitive cost. Additional research projects which are underway and will continue in FY 1987 include the development of a thermochemical cell in which spent chemicals would be regenerated by solar energy to produce electricity. Additionally, several present methods for producing solar thermal electricity generating systems are limited to operation below 750°F due to excessive thermal losses. Researchers will continue to study approaches for replacing the sensible heat transport methods with thermochemical energy transport and storage processes which have the potential to dramatically reduce thermodynamic losses and thereby increase overall efficiency. Experiments addressing the technical feasibility of thermochemical transport will also be undertaken.

Biofuels

Biofuels energy technologies utilize a variety of organic feedstocks, such as terrestrial and aquatic crops and municipal waste, which can be converted by thermochemical and biochemical processes into high-value gaseous,

liquid, and solid fuels. Biofuels currently are supplying approximately 2.7 quads or almost 4% to the U.S. energy supply. Development of advanced biofuels technologies offers the potential for significant additional contributions over the longer term. The FY 1987 budget request for Biofuels Energy Systems is $11.6 million for operating expenses and $0.6 million for capital equipment. During FY 1987, the Biofuels Program will focus on key long-range research and development issues to provide a technology base for private sector development of biofuels production and conversion technologies.

Feedstock production research supported within the Budget Request in short-rotation intensive culture will include genetic selection to improve biomass yields, along with examination of monoculture plantings to determine operational yields and susceptibility to disease and pests. Research on herbaceous energy crops will focus on screening of promising species which can be grown on marginal croplands, as well as small-scale experimental plots. Aquatic species research will include species screening, genetic research, and small-scale experiments to improve the productivity of microalgal species and the efficiency of conversion processes.

Thermochemical conversion research will focus on liquefaction and pyrolysis of biomass feedstocks to produce high-value liquid and gaseous fuels. Municipal solid waste research will continue to address the production of liquid and gaseous fuels via thermal liquefaction and gasification. Combustion kinetics and emissions research will also be conducted.

Research in biochemical conversion will focus on improving processes for conversion of organic materials to alcohol fuels in order to advance the technology for competitive production of octane enhancers and additives for transportation fuels. Research in the anaerobic digestion of municipal waste will address the improvement of microorganisms, as well as attempt to understand the biochemistry and physiology of the anaerobic digestion process.

Wind Energy

Updated information, recently received, indicates that there are presently over 13,000 wind turbines operating in the U.S. with an installed capacity greater than 1100 MW. However, many areas remain where continued research efforts are needed to establish the knowledge base necessary for industrial development of viable wind technology within the context of evolving competitive and unsubsidized electric energy supply markets. It is the objective of the Wind Energy Research Program to improve the understanding of fundamental atmospheric fluid flows and their effects on wind turbines and to translate this understanding into tools that industry can use to design and develop improved, more reliable, cost competitive wind turbines. The FY 1987 budget request of $8.1 million for operating expenses and $.2 million for capital equipment will fund the research required to accomplish these objectives.

Commercial development which started at the 50 kw size has now moved into the 100-200 kw range. With the success of those tests and the current successful operation of the larger Mod-2 experiments, sufficient data is now available to industry to proceed with larger systems. The large experimental Mod-2 and

Mod-5 projects will be closed in FY 1987 to concentrate resources on fundamental structural and aerodynamic research to benefit all system sizes.

Major improvements in turbine energy capture are believed to be achievable through aerodynamics research activities. Tests on specially instrumented commercial machines will continue in order to collect actual operating data in a wide range of environments. This will improve the understanding of the performance of different turbines' energy capture as it is affected by turbulence, wakes, and micro-siting and will further the development of air foils tailored to wind turbine requirements.

FY 1987 structural dynamics research activities will improve the understanding of how aerodynamic loads induce structural stresses and rotor and tower material fatigue. Research efforts are aimed at the development of predictive models which take into account the complex interactions of forces on wind machines. Cooperative field assessment activities with industry are used in this area to acquire the data necessary to verify theories.

Advanced component development involves the application of basic science and research on aero and structural dynamics to develop components that could lead to major improvements in the energy production of advanced wind turbines. This area also includes studies on environmental effects of wind turbines, application of wind turbines as fuel savers with diesel generators for remote power generation, and on the interaction of wind machines with existing utility power systems.

Ocean Energy

The Ocean Program conducts the research and development of ocean energy technology to a point where the private sector can make competent assessments of whether applications of the technology are viable energy supply alternatives. This will be accomplished through appropriate research on components and systems modelling. The OTEC program is guided by a long-range goal to investigate the technologies which could reduce the capital cost of the OTEC systems to $3200/kWe (1984 dollars). The program strategy focuses on reducing the technical uncertainties associated with a 5-15 MWe, near-shore OTEC system which serves as an approximation of the incremental capacity requirements of the type of markets representing the likely point of initial competitiveness for this technology. The FY 1987 budget request is $2.5 million for operating expenses.

The emphasis of the FY 1987 Ocean Program will be placed on experimental verification and testing and thermodynamic research and analysis. Material and structures research and oceanographic, environmental, and geotechnical research previously undertaken have provided a data base that is useful for the two FY 1987 research areas, but do not currently require the degree of emphasis that was necessary in past years.

The objective of the experimental verification and testing program is to provide a facility for private industry to conduct seawater tests and experiments which verify OTEC component functional feasibility, performance, and operational characteristics on a scale which can be extrapolated for use in modular systems applicable to small plants. The FY 1987 budget will also

provide funds to upgrade the Seacoast Test Facility by expanding the capacity of its seawater systems for open-cycle OTEC experiments.

One objective of the thermodynamic research and analysis program is to experimentally determine the effects of seawater and non-condensible gas on open-cycle heat and mass transfer processes. The program will also validate selected power system analytical models at a scale sufficient to extrapolate a generic understanding of how to design potentially cost-effective open and latent-heat power systems which could meet the cost goals of the program. Reaching this goal is dependent upon increasing the output of the power system and significantly reducing the life cycle cost.

Other Solar Activities

The FY 1987 budget request for the efforts in support of planned research activities is $8.1 million for operating expenses and $.6 million for capital equipment. These efforts include international, technology transfer, and resource assessment programs, the Solar Energy Research Institute, and program support and direction.

Technology transfer activities such as publications summarizing research results across individual investigations and performing centers are important mechanisms for transferring information to the R&D community in context and provide the basis for facilitating information exchange and dialogue. Additionally, continuing requests are received for information from a more general cross section of the public and the energy community concerning

renewable energy. The FY 1987 budget request of $1.9 million for operating expenses and $.1 million for capital equipment will continue the technical and public information services at levels commensurate with solar research and development activities.

The international solar energy program provides Federal organizations and industry with a vehicle for cooperative international trade development for renewable energy. DOE is responsible for chairing an interagency committee, the Committee on Renewable Energy Commerce and Trade (CORECT) which provides a forum where industry and public entities can coordinate the use of existing resources and authorities to exploit export opportunities for the domestic solar energy industry. Additionally, funds are used to conduct a program managed by the Department of Commerce which cost shares, with industry, the development and presentation of exhibitions, special trade missions and trade development services with a continuing focus on international markets of more significant potential. The FY 1987 budget request is $.5 million for operating expenses.

The FY 1987 budget request of $.5 million for the Solar Energy Research Institute will fund capital improvements to the permanent DOE facilities that will improve efficiency, safety and security.

Solar resource assessment activities will provide information regarding the distribution and spectral and temporal variability of solar energy resources throughout the United States. The FY 1987 budget request for these activities is $.7 million. Coordination of these activities and other ongoing research and development activities is an important part of the program support and

direction functions. FY 1987 requests of $.9 million for program support and $4.1 million for program direction funds will, among other things, provide technical and crosscutting studies of the various solar technologies, provide for updates to multi-year program plans, continue technical and programmatic dialogue with industry, and manage the diverse research activities in the national solar research program.

Geothermal Energy

The Geothermal Energy Program carries out research and development, in cooperation with industry, on an array of geothermal resource types (including geopressured, hydrothermal, hot dry rock, and magma) and conversion technologies designed to define the technical and economic boundaries of this vast domestic energy supply resource. Program activities include applied research, technology development, and information efforts which provide the basis for the timely introduction of new concepts and products into the marketplace by the private sector. The FY 1987 budget request for the Geothermal Program is $17.9 million for operating expenses.

The purpose of the geopressured research program is to define the technical characteristics and recoverability of this large resource of hot brine and methane which lies primarily beneath the U.S. Gulf Coast. The FY 1987 program includes experimental well flow testing, tests of the conversion of the combined energy content (thermal and chemical) to electricity, and supporting research on the dynamic response of geopressured reservoirs to production conditions, chemical constituents of the brine, and the possibility of land subsidence.

Hydrothermal research will allow the expansion of the accessible resource base through an improved understanding of the processes for extraction and reinjection of geothermal fluids; new materials capable of withstanding high temperatures, high pressures, and highly corrosive environments; brine chemistry research leading to techniques to prevent plugging of wells and pipes; advanced power cycle technologies; field testing techniques for appraising very high temperature geothermal resevoirs at the Salton Sea Scientific Drilling Project; and the experimental study of survey methods applicable to young and andesitic volcanoes.

Hard rock penetration research will be performed jointly with industry to improve the technology and reduce the uncertainty of geothermal well drilling, which currently represents about half of the cost of geothermal power and exceeds the cost of typical petroleum wells by factors of two to four due to the fact that geothermal wells are generally deeper, and encounter harder rock, higher temperatures, and more corrosive fluids than do oil and gas wells. Experimental programs include high-pressure water jets combined with rock cutters, mechanics of rock penetration, and drilling fluid loss control.

Research will also be carried out to determine the depth and size of a large continental magma chamber, to evaluate alternative methods of energy conversion, and to develop materials and instrumentation capable of operations in the 1000 degree Celsius magma environment.

Hot dry rock research involves the evaluation of the properties of deep crystalline rock and the development of methods to extract geothermal heat

from such resources. In FY 1987, the experimental extraction of heat from the large fractured reservoir at Fenton Hill, New Mexico, will begin and research on improved diagnostic technologies including microseismic measurements will be extended to higher temperatures.

Geothermal Resources Development Fund

The Geothermal Resources Development Fund was established to broaden the geothermal energy technology base by guaranteeing loans for private sector development of several state-of-the-art facilities. The FY 1987 request is $72,000, which allows for evaluating projects, restructuring existing guarantee agreements, and monitoring outstanding loans.

Hydropower

Small-scale hydropower technology is nearing maturity and the DOE program has succeeded in providing the necessary technology base to industry. Therefore, no funds are requested for FY 1987. Ongoing contracted analytical and technical support will begin to phase out. The remaining technology development and R&D projects will then be monitored by DOE personnel to ensure that contractual and reporting requirements are met. By the end of FY 1986, seventeen of the nineteen technology development projects will be on-line, with the remaining 2 becoming operational in FY 1987. The low-cost crossflow turbine and free-flow turbine R&D projects are expected to go on-line in FY 1986 and the siphon penstock R&D project will be operational in FY 1987.

Electric Energy Systems

The Electric Energy Systems Program conducts research to establish a technology base that will lead to advanced concepts and materials that will enable future electric networks to meet the national security need for a reliable electric supply while maintaining the health and safety of society. The Program supports research to resolve mid- to long-term problems in order to ensure that the biological health effects and risks to life forms exposed to high-voltage electric and magnetic fields are well understood and mitigated; to provide options that will ensure appropriate system reliability and promote the efficient use of resources in the Nation's future electric network; to provide electric power over a wide range of system conditions including both normal and emergency situations; and to improve the efficiency of electric systems through the development of new materials, advanced controls, and new design concepts. The FY 1987 budget request is $7.6 million for operating expenses.

Researchers in reliability R&D activities will continue to assess the potential impact of a nuclear electromagnetic pulse on the Nation's electric network and to provide advanced techniques for control and protection of systems during normal and abnormal operations. In FY 1987 the reliability research will include a second-level impacts assessment.

Funds requested in the systems technology research activity are required to meet contractual obligations to complete several current programs. New materials research will be carried out on liquid dielectrics and semiconductors.

Energy Storage

The Energy Storage program is developing a technology base for advanced energy storage and conversion systems that will facilitate the use of abundant and intermittent energy sources. Three promising energy storage technologies are now being pursued: battery (electrochemical), thermal, and chemical/hydrogen. The FY 1987 budget request for the Energy Storage program is $8.6 million.

The battery storage technology base research activities encompass fundamental research with the objective of providing the basis for improvements in efficiency, power density, energy density, and lifetime in new electrochemical couples and small-scale fuel cells. In FY 1987, the aims of the technology base research will be to provide a better understanding of the complex phenomena that determine electrochemical activity; explore new electrochemical couples with improved performance characteristics; develop improved materials and new components for advanced battery technologies to solve key technical problems; and identify new, low-cost catalysts for electrochemical energy conversion systems.

The objectives of the advanced development activity include development and evaluation of high-performance, long-life, economical batteries for future mobile and stationary energy storage applications. In FY 1987, the exploratory technology development activities will concentrate on investigating key problems in sodium/sulfur batteries which have the potential for providing up to five times the energy storage capability of conventional batteries. Research will include identifying new materials and designs for electrolytes and electrodes.

The thermal and mechanical energy storage activity will provide the technical underpinning for the more effective use of thermal energy sources and improving the efficiencies of chemical/hydrogen production and storage. Activities in FY 1987 will emphasize chemical/hydrogen research on high-temperature electrolysis and advanced storage options to achieve lower cost in hydrogen liquefaction. The thermal storage program will conduct research on form-stable phase-change materials in the high-temperature range and will explore advanced storage concepts.

CONCLUSION

Mr. Chairman, I believe that the budget that I have summarized will contribute to increased energy supply diversity and end-use efficiency and should serve to promote increased competition in the marketplace. I believe that this budget request will allow us to address the items of highest priority in research and development in the fields of energy conservation and renewable energy and thereby contribute to the accomplishment of our national goal of fostering an adequate supply of energy at reasonable cost. This is a budget which I believe seriously recognizes today's fiscal responsibilities, as well as tomorrow's anticipated needs.

Senator DOMENICI. Thank you very much.

Acting Secretary Bauer, we will make your testimony part of the record. If you would like to summarize it, we would appreciate it.

STATEMENT OF DONALD L. BAUER, ACTING ASSISTANT SECRETARY, FOSSIL ENERGY, DEPARTMENT OF ENERGY

Mr. BAUER. Thank you, Mr. Chairman. It is also my pleasure to appear before the subcommittee in support of the fiscal year 1987 budget for fossil energy.

The administration's proposed budget for fiscal year 1987 is $150.1 million in total budget authority. The request was fashioned from the same fiscal principles and goals that made up the President's overall budget submission. That is, a budget submission that meets the targets imposed by the Gramm-Rudman-Hollings legislation.

The fossil energy budget request would also maintain adequate spending levels for those functions that would not otherwise be performed by the private sector; that is, the generic high risk, long-term research.

It also ensures that adequate funds are available for research that benefits the general population; for example, the Federal assistance for those technologies that can economically manage the environmental impacts of fossil fuels. It will continue to build on a broad base of scientific data that will help shape the fossil fuel technologies of the 21st century.

Perhaps more importantly, by reflecting the administration's commitment to fiscal constraint, the fiscal year 1987 budget for fossil energy will do its fair share in helping bring Federal spending under control. The $150-plus million will be offset by $67 million in prior year funds and construction program transfers; therefore, the new budget authority amounts to just under $83 million.

Included in our budget request this year is a new initiative for a cooperative R&D venture in fossil energy. This approach would be used in the applied research area, focusing on general categories of extraction-related technologies that we believe will attract significant industrial interest.

These technologies initially will include unconventional gas recovery, enhanced oil recovery, oil shale processing and underground coal gasification. This initiative that we have is intended to give the private sector a greater role in establishing the Federal R&D priorities. It will help us ensure that tax dollars are applied to those research efforts that are most relevant to the trends and objectives of the marketplace. It will also assist in the transfer of taxpayer-supported technology from the Government to industry. It will provide greater leverage for Federal funds by increasing private sector cost sharing.

We recognize that additional details must be developed before the initiative can be implemented; therefore, we intend to work closely with Congress in developing this approach and provide to you the results of that as we go on with the implementation.

I should also mention, Mr. Chairman, that in addition to the funds requested for conducting the fundamental research and development efforts in fossil energy, the Department will also be car-

rying out the congressionally directed Clean Coal Technology Program budgeted at $397.6 million for fiscal fears 1986 through 1988.

On February 17, the Department issued the "Program Opportunity Notice" outlining the program's objectives, the requirements, the criteria and the dates for submission of the proposals. As required by the act, the proposals are due to the Department by April 18, and we will make a selection of prospective projects on or before August 1, 1986, of this year.

So when that Clean Coal Technology Program is complete, the demonstration projects it will have financed are expected to provide sufficient technical, economic, environmental, health and safety, and operational information at sufficient scale to enable the marketplace to make future commercial decisions.

That completes my statement, Mr. Chairman.

[The prepared statement of Mr. Bauer follows:]

FY 1987 FOSSIL ENERGY BUDGET REQUEST

Statement of Donald L. Bauer
Acting Assistant Secretary for Fossil Energy
U.S. Department of Energy

Before the

Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development
U.S. Senate

March 17, 1986

FY 1987 FOSSIL ENERGY BUDGET REQUEST

On February 5, 1986, President Reagan sent to the U.S. Congress his proposed federal budget for fiscal year 1987 — the first budget submitted in the Gramm-Rudman-Hollings era.

Contained within the Administration's proposed budget is a request for $150.1 million in total budget authority to continue fossil energy research. The request — part of approximately $1.82 billion proposed by the Energy Department in FY 1987 for energy research and development — embodies many of the same fiscal principles and goals as the President's overall budget submission.

It maintains adequate spending levels for those functions that would not otherwise be pursued by the private sector, i.e., generic, high-risk, long-term research. It ensures that adequate funds are available for research that truly benefits the general population, i.e., federal assistance for technologies that can economically manage the environmental impacts of fossil fuels. It continues to build a broad base of scientific data that will help shape the fossil fuel technologies of the 21st Century.

But perhaps most importantly, by reflecting this Administration's commitment to fiscal constraint, the FY 1987 Fossil Energy budget request will do its fair share in helping to bring federal spending under control and removing the last remaining obstacle to a future of continued economic growth.

Specifically, the Administration's FY 1987 budget request for Fossil Energy Research and Development can be summarized as follows:

	Budget Authority
Coal	$ 82.227 million
Petroleum	9.890 million
Gas	5.252 million
Program Direction & Management Support	40.221 million
Cooperative Venture Pool	12.500 million
Subtotal	$ 150.090 million
Prior Year Offsets	- 64.811 million
FE Construction Transfer	- 2.075 million
Appropriation Transfers	- .437 million
Subtotal	$ -67.323 million
TOTAL (new Budget Authority)	$ 82.767 million

DEFERRALS AND OTHER OFFSET/TRANSFERS

As the above table shows, the Energy Department is proposing to conduct a fossil energy research program in FY 1987 at a total funding level of slightly more than $150 million. However, this budget figure can be significantly reduced in line with the Administration's funding priorities by applying currently unspent funds principally from those added in FY 1986 during the Congressional appropriations process. These proposed deferrals are associated with the following programs (FY86 proposed deferral amount is in parentheses): magnetohydrodynamics ($13.130 million), fuel cells ($22.056 million), surface coal gasification ($ 8.008 million), coal liquefaction ($ 6.329 million), control technology and coal preparation ($ 4.875 million), advanced research and technology development ($ 2.096 million), combustion systems ($ 0.951 million), heat engines ($ 1.428 million), oil shale ($ 2.856 million), program direction and management support ($ 0.476 million).

In addition to the proposed deferrals, the FY 1987 fossil energy budget can be further offset by applying appropriation transfers of $2.075 million in unspent funds from prior year construction projects and $0.437 million in fees previously deposited in the "Energy Security Reserve" for guarantees of obligations for the Great Plains Coal Gasification Project.

COOPERATIVE R&D VENTURES POOL

The FY 1987 budget request includes a new initiative for a cooperative R&D venture approach in fossil energy. This new approach would be used in the applied research area, focusing upon general categories of technologies that are sufficiently mature to attract significant industrial interest.

In FY 1987, the Fossil Energy program proposes to make available $12.5 million for an initial phase-in effort that will help us to determine the best strategy for applying the cooperative venture mechanism, to stimulate interest within different parts of the energy industry, and to develop practices that will help us realize, as much as possible, the benefits of this approach.

Initially, the Fossil Energy program will confine the cooperative R&D venture pool to extraction-related technologies, such as:

- o unconventional gas recovery
- o oil shale processing
- o enhanced petroleum recovery
- o underground coal gasification

The program will also be open to other R&D concepts applied to U.S. deposits of oil, gas and shale that might be brought to the Department for consideration.

We recognize that there may be some initial reluctance in the marketplace to shift toward a different funding approach for industrial performed energy R&D. But that should not argue against the increased economic efficiency, market penetration, and more effective technology

transfer offered by an improved funding mechanism. The cooperative venture initiative is intended to give the private sector a greater role in establishing federal R&D priorities. It will help ensure that tax dollars are applied to those research efforts that are most relevant to the trends and objectives of the marketplace. It will assist in the transfer of taxpayer-supported technology from the government to industry. And it will provide greater leverage for federal funds by increasing private sector cost-sharing.

The Department will not place tight constraints on the types of cooperative opportunities to be considered. As currently envisioned, however, the proposed program would solicit proposals with the following common characteristics:

- o DOE will be a minority funding partner with at least two other industrial partners; the federal share will provide a maximum of 49 percent of the total funding for the venture;
- o Assurance must be available that federal funds will not be displacing private sector funds;
- o The taxpayer must be able to share in royalties or other profits from the venture, consistent with the government's funding contribution;
- o Preference will be given to companies with a proven record of successfully obtaining and managing co-funding from private sources.

We recognize that additional details must be developed before this new initiative can be implemented. Therefore, we intend to work closely with Congress in developing a viable, effective venture pool approach that results in an efficient expenditure of tax dollars.

Further discussion of the FY 1987 Cooperative R&D Ventures Pool initiative can be found on pages 25-26 of this testimony.

CLEAN COAL TECHNOLOGY PROGRAM

In addition to the funds requested for conducting a basic and applied research program in fossil energy, the Department will also carry out the Congressionally-directed Clean Coal Technology Program, budgeted at $397.6 million for fiscal years 1986 through 1988.

On February 17, 1986 the Department issued a "Program Opportunity Notice" outlining the program's objectives, the evaluation criteria and the information requirements for prospective proposers. In accordance with Public Law 99-190, which made the funds available, the Department will require a minimum of 50 percent sharing of project costs by the private sector. The Department will also require that such cost sharing be on a dollar-for-dollar basis as expended during each phase of the selected projects. To ensure the broadest spectrum of cost-shared clean coal projects, the Department will accept proposals in all energy market applications. As required by P.L. 99-190, proposals are due on April 18, 1986, and selection of prospective projects will be made on or before August 1, 1986.

When the Clean Coal Technology Program is complete, the demonstration projects it will have financed are expected to provide sufficient technical, economic, environmental, health and safety, and operational information at sufficient scale to enable the private sector to make rational commercialization decisions.

Additional details on the Clean Coal Technology Program can be found on pages 27-28 of this statement.

The following pages contain a more detailed description of the proposed FY 1987 Fossil Energy budget organized by major activity:

- COAL -

CONTROL TECHNOLOGY AND COAL PREPARATION

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$34.8	$33.3	$31.9	$18.1	-43.3%
Deferral to Finance FY87	...	...	-4.9	...	...
Total	$34.8	$33.3	$27.0	$18.1	-33.0%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

Coal preparation is directed toward the development of advanced coal cleaning technologies that will reduce the ash and sulfur content of U.S. coals. The resultant product can be formulated into a high quality fuel that could replace oil and/or gas and reduce environmental emissions of suspected acid rain precursors from coal-fired power plants in both new and retrofit applications.

The FY 1987 coal preparation budget proposal of $6,443,000 provides funds to:

- o Complete design of pre-proof-of-concept Gravimelt chemical coal cleaning system. ($1,000,000)
- o Continue investigation of advanced concepts for chemically modified coals. ($1,300,000)
- o Continue joint DOE/EPRI advanced coal cleaning development and test program. ($1,000,000)
- o Continue research to optimize techniques for microbial removal of organic sulfur from coal. ($1,000,000)
- o Continue ultrafine coal characterization and process economics. ($500,000)
- o Continue in-house research on chemical coal cleaning, and fundamental organic sulfur chemistry. ($500,000)
- o Continue laboratory scale research on advanced physical cleaning concepts. ($1,143,000)

Flue gas cleanup addresses the removal of pollution causing contaminants from the stack gases of conventional combustion units to meet environmental standards. Efforts will be focused on fundamental research for processes for the combined removal of NO_x, SO_x, and particulates, both for utility and industrial applications.

The FY 1987 funding request of $7,541,000 would:

- Complete proof-of-concept test and evaluation for low temperature dry hydrate and dolomitic lime slurry in-duct injection for acid rain precursor control technology process candidates. ($3,390,000)
- Continue research on advanced NO_x/SO_2 chemistry and bench scale advanced concept development. ($2,341,000)
- Continue fluidized bed copper oxide proof-of-concept test and evaluation. ($1,810,000)

Gas stream cleanup includes the technology for removal of contaminants from gasifier and combustor process streams prior to utilization in advanced power conversion cycles such as gas turbines and fuel cells. Both hardware and environmental protection are key concerns.

The $3,839,000 in funds requested for FY 1987 would:

- Continue alkali combustion chemistry research. Work will be performed by Midwest Research Institute in Kansas. ($350,000)
- Continue process modification R&D for trace contaminants. ($75,000)
- Continue R&D for sulfur removal with selected sorbents. ($788,000)
- Continue process modification R&D for direct-fired turbine. ($1,000,000)
- Complete on-line tests of remaining selected particulate and sulfur removal devices for turbine combined cycle. ($600,000)
- Continue test and evaluation of soot, particulate control, and trace contaminants. ($100,000)
- Continue basic research for physical and chemical cleanup for gasifier PFB and direct coal-fired turbines including instrumentation and control. ($926,000)

Waste management focuses primarily on waste sampling and characterization from coal preparation wastes. The FY 1987 funding request of $324,000 would:

- Continue sampling and characterization and data acquisition of organic and inorganic compounds present in solid wastes and in their leachates. ($195,000)
- Complete Phase I R&D for extracting energy from coal preparation wastes. ($129,000)

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$30.8	$35.2	$33.8	$27.2	-19.5%
Deferral to Finance FY87	...	...	-2.1	...	...
Total	$30.8	$35.2	$31.7	$27.2	-14.2%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The Advanced Research and Technology Development Program is directed toward the scientific and technical areas that underlie the development of all fossil energy technologies. Included are fundamental studies to increase understanding of the mechanisms of direct coal combustion, generic studies of materials and components, and investigations of instrumentation concepts in environments associated with advanced coal technologies.

AR&TD differs from the Fossil Energy line programs; the latter have an end-item technology development orientation while AR&TD's mission is to pursue generic research in support of all Fossil Energy coal line programs.

The $27,224,000 requested for AR&TD would be applied as follows:

Direct Utilization ($9,415,000)

- Continue research on the determination of physical and chemical properties of uncombusted coals and combustion products. ($950,000)
- Continue support research on coal combustion science and IEA coal combustion science program. ($4,643,000)
- Continue research on deposition mechanisms and erosion caused by mineral matter in atmospheric, internal combustion, and pressurized environments. ($1,845,000)
- Continue research on separation mechanisms relevant to the coal fuel cycle, from coal beneficiation to the removal of environmentally deleterious products of combustion. ($1,127,000)
- Continue generic electrochemistry research and research on fundamental aspects of molten carbonate and solid oxide fuel cells. ($850,000)

Materials ($5,860,000)

- Perform mechanistic research necessary to allow development and use of new corrosion and erosion resistant alloys, ceramics and refractories for use in coal conversion and utilization systems. ($5,860,000)

Components ($1,593,000)

- Conduct studies on novel component concepts to mitigate erosion and wear in seals; and on slurry flow control devices. ($650,000)
- Conduct fundamental research at national labs and PETC on bulk flow modeling, solids-liquid rheology, and dense phase solids-gas flow; eliminate support for university research in solids transport. ($943,000)

Environmental Activities ($2,200,000)

- Continue analyses of issues associated with air and water quality, solid waste disposal, and toxic substances; continue support of occupational health and safety compliance services. ($1,550,000)
- Continue research conducted under ITFAP with reduced emphasis on quality assurance of data and analytical tools. ($650,000)

Technical and Economical Analysis ($2,000,000)

- Continue funding studies which support multi-year planning and FE strategy and program formulation, technical/economic assessment studies that crosscut a number of FE programs, and support of IEA/Coal Research Service. ($2,000,000)

Technology Base Synthesis ($800,000)

- Continue analyses and studies to integrate and coordinate research and exploratory development activities, to identify advanced research needs, to support international collaborative research activities in FE, and to provide seed funding for new advanced research initiatives. ($800,000)

Instrumentation, Control and Diagnostics ($1,356,000)

- Perform research on unique methods for measuring multiphase flow parameters such as velocity, solids content, and viscosity; and for identifying chemical species such as plasma spectrographic techniques. ($1,356,000)

University Coal Research ($4,000,000)

- Initiate approximately 20 new university projects relating to coal science, environmental science, surface science, organic and inorganic chemistry of coal constituents and the mechanisms and kinetics of chemical reactions to gasification, liquefaction and combustion; encourage collaboration between university and industrial researchers. ($4,000,000)

COAL LIQUEFACTION

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised[1/]	FY 1987	Percent Change from FY 1986
Operating Expenses	$31.1	$32.9	$31.6	$9.1	-71.2%
Deferral to Finance FY87	...	...	-6.3	...	...
Total	$31.1	$32.9	$25.3	$9.1	-64.0%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The Coal Liquefaction program is developing the scientific and engineering knowledge base which industry can use to bring economically competitive and environmentally acceptable synthetic liquid fuel technology into the marketplace when needed.

The FY 1987 budget request of $ 9,147,000 would be used as follows:

Advanced Research ($2,620,000)

- Conduct exploratory efforts on novel coal liquefaction processes. ($200,000)
- Continue research to improve the understanding of coal liquefaction including properties of coal, reaction mechanisms, utilization of hydrogen, and properties of coal liquids. ($1,120,000)
- Continue research on biological approaches to coal liquefaction. ($100,000)
- Continue research on novel catalytic approaches to coal liquefaction. ($450,000)
- Continue research on the physical, chemical and thermodynamic properties of fossil fuel liquids. ($750,000)

Indirect Liquefaction ($2,539,000)

- Continue catalyst research, study reaction mechanisms and more promising process concepts at PETC and with industry. ($2,539,000)

Direct Liquefaction ($2,996,000)

- Continue in-house research of advanced process concepts at PETC while completing existing bench scale industrial projects. ($2,996,000)

Support Studies/Engineering Evaluations ($992,000)

- Complete one existing industrial instrument research project. ($37,000)
- Continue technology base research and an existing industrial research project ($955,000)

COMBUSTION SYSTEMS

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$30.1	$30.3	$29.1	$9.2	-68.4%
Deferral to Finance FY87	...	...	-1.0	...	...
Total	$30.1	$30.3	$28.1	$9.2	-67.3%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings).

The goal of the Combustion Systems activity is to increase the contribution of the nation's coal resources through the development of market-suitable combustion systems and fossil-derived fuels. The programs within the overall Combustion Systems activity are Atmospheric Fluidized Bed, Pressurized Fluidized Bed, Alternative Fuels and Advanced Combustion Technology.

The FY 1987 funding request of $9,169,000 would be used as follows:

Atmospheric Fluidized Bed Combustion ($1,590,000)

- Conduct in-house fluidization research in particle motion flow, erosion, bed internals and heat transfer surfaces. ($490,000)
- Initiate bench scale construction and testing of special AFB applications for the commercial/institutional and residential sectors. ($1,100,000)

Pressurized Fluidized Bed Combustion ($3,686,000)

- Continue ongoing program at New York University to evaluate PFB components and design changes to enhance performance and provide the basis for advanced concept designs. ($600,000)
- Continue research on PFB dynamics, systems analysis, and combustion characterization; continue technology and economic analysis assessments. ($586,000)
- Continue the follow-on test program to obtain POC on hot gas cleanup, coal/water slurry feeding, and performance of updated heat exchanger design. ($1,500,000)
- Complete Phase I systems definition studies including conceptual design and cost of a commercial plant. Initiate Phase II, development and testing of key critical process components. ($1,000,000)

Advanced Combustion Technology ($1,882,000)

- Continue development of the most promising of the light industrial, commercial and residential concepts selected including design, fabrication and testing. ($1,400,000)
- Continue in-house activities supporting advanced combustion technology systems. ($482,000)

Alternative Fuels ($2,011,000)

- Complete detailed combustion and system characterization and technical, economic, and environmental assessments on selected existing residential boiler/furnance systems firing CLM/micro-coal fuels. ($2,011,000)

FUEL CELLS

(Dollars in Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$40.5	$35.4	$34.1	$5.0	-85.3%
Deferral to Finance FY87	...	...	-22.1	...	...
Total	$40.5	$35.4	$12.0	$5.0	-58.3%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The Fuel Cell program supports high risk, high payoff technology base development to assist private industry in developing hydrocarbon fuel conversion technologies. Fuel cells, which rely on an electrochemical reaction rather than combustion, can potentially increase the cost effectiveness, efficiency, and environmental acceptability of conventional and alternative hydrocarbon fuels.

No funds are requested in FY 1987 for phosphoric acid fuel cell systems. The objective for this program will have been achieved by the end of FY 1986 and full responsibility for further development and application of phosphoric acid fuel cell technologies should be left to the private sector.

The technical feasibility of molten carbonate fuel cells operating at approximately 60 percent electrical conversion efficiency (natural gas to busbar) has been forecasted by single cell testing. The complexity and associated capital costs of advanced fuel cell systems are projected to be less than those for first generation phosphoric acid fuel cell systems. The $3,400,000 requested for the molten carbonate fuel cell will be used to:

- Continue development of external and/or internal reforming molten carbonate stacks. ($2,600,000)
- Continue technology base research on cell components and corrosion resistant materials. ($800,000)

The solid oxide fuel cell is an advanced, high temperature solid state fuel cell that offers promise in electric utility and in cogeneration applications in industrial and commercial sectors. Solid oxide electrolyte fuel cells have the advantage of solid state stability and have been projected to be more easily manufactured than other fuel cell concepts. The $1,600,000 requested for the Advanced Concepts fuel cell activity would:

- o Complete testing of a 5 kW solid oxide fuel cell module and continue development of a 25 to 200 kW generator. ($1,600,000)

HEAT ENGINES

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expense	$11.8	$12.8	$12.3	$7.9	-35.8%
Deferral to Finance FY87	...	...	-1.4	...	...
Total	$11.8	$12.8	$10.9	$7.9	-27.5%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of this program is to establish technical data which will enable the private sector to assess the commercial viability of coal-fueled power conversion systems. The program focuses on key technical problems associated with substituting coal or coal-derived gaseous fuels for distillate fuels or natural gas in gas turbine and diesel power conversion systems. The goal is to assist the private sector, through selected research efforts, in developing the technology needed for direct firing of coal, either dry or suspended in a liquid carrier, or a coal-derived gaseous fuel cleaned at minimal cost.

The $7,942,000 in requested funds for FY 1987 will be used as follows:

Gas Turbines ($6,394,000)

- Complete first portion of the integrated systems test program. ($5,994,000)
- Continue evaluation of coal-liquid mixtures in the gas turbine combustor test stand. ($400,000)

Diesels ($1,548,000)

- Continue evaluation of coal-liquid mixtures in the diesel engine test facility. Initiate research activities related to the FY 1986 Program Research and Development Announcement for the coal-fired diesel engine integrated systems test validation. Complete technical and economic analyses and related experimental tests of the coal-fired diesel engine project. ($1,548,000)

UNDERGROUND COAL GASIFICATION (Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$ 5.7	$ 4.2	$ 4.1	$ ...	-100.0%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

Underground Coal Gasification (UCG) is a process for converting coal, in place (in situ), to a readily cleanable synthetic gas comparable to that produced from surface gasification systems. The energy for the process is derived from partial combustion of the coal (pyrolysis) resulting in the identical reactions that occur in aboveground gasification. The technical feasibility of underground gasification techniques applied to several types of coal resources has been proven. In FY 1986 and FY 1987 ongoing technology base activities will be phased out. In FY 1987 industrial-proposed applied research efforts will be candidates for the cooperative R&D venture pool.

Gasification Technology Development ($0)

- Complete technology base development using prior year funds.

Environmental and Advanced Research ($0)

- No activity.

MAGNETOHYDRODYNAMICS

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$30.7	$28.9	$27.7	$ ...	-100.0%
Deferral to Finance FY87	...	...	-13.1	...	...
Total	$30.7	$28.9	$14.6	$ ...	-100.0%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The current MHD program continues the implementation of the June 1984 cost-shared multiyear program which provides for basic supporting research and the development of systems/subsystems which will provide proof-of-concepts needed for the advancement of the MHD technology to the retrofit stage.

No funds are requested for MHD research in FY 1987. The Department believes that the cost of continuing its MHD program is not affordable in light of current fiscal constraints. Other technologies can contribute more directly to the nation's energy security with lower investment requirements, in a more timely manner and with significantly more cost-sharing.

SURFACE COAL GASIFICATION

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$35.1	$43.0	$41.3	$5.6	-86.4%
Deferral to Finance FY87	...	...	-8.0	...	...
Total	$35.1	$43.0	$33.3	$5.6	-83.2%

Specific programmatic goals of the Surface Coal Gasification Program are to: (1) advance the state-of-the-art of Surface Coal Gasification technology to optimize its potential for development of more viable or advanced gasification systems through the study of promising long term, high risk concepts, (2) identify and support those R&D efforts that will make available the full capabilities and processing flexibility of surface coal gasification systems as the key coal conversion technology directly applicable for

generating alternative energy options from coal for every sector of the energy consuming marketplace, and (3) continue management and monitoring of the Great Plains Gasification project as necessary.

The $5,598,000 requested for FY 1987 would be applied to the following research efforts:

Advanced Research ($968,000)

- Continue research on the fundamental chemistry and reaction mechanisms associated with mild gasification and investigate the parameters that control product yield distribution. ($593,000)

- Continue research on the chemistry of ash and slag from coal gasifiers ($375,000).

Advanced Process Development ($1,689,000)

- Complete studies on advanced staged, concurrent rapid rate reactors to enhance data base on rapid rate pyrolysis. Continue characterization of char during devolatilization. ($309,000)

- Continue studies using coal based sorbents and zeolites in pressure swing adsorption for separation of gases. Continue development of low cost, highly selective permeable membranes for hydrogen separation. ($235,000)

- Continue operation of the advanced gasification concepts facility to generate data essential to advancing entrained gasification and hot gas cleanup technology. ($192,000)

- Continue theoretical studies on coal gasifiers and gasification systems needed for design of optimized systems. ($703,000)

- Redirect and continue essential studies leading to economic production, upgrading and use of new fuel forms. ($250,000)

Systems Engineering Concepts ($1,373,000)

- Continue to investigate parameters controlling the use of minimally cleaned gasifier coal products as fuels for advanced heat engines. ($50,000)

- Continue effort to develop more economical methods for production of oxygen in large quantities--advance the solid state zirconia system to the "process development unit" stage of study. ($350,000)

- o Utilize results of studies on composite sorbents, mixed metal oxides, catalysts, etc. to establish reaction mechanisms by which gasifier performance can be controlled through use of in-bed/coal-feed additives. ($200,000)

- o Continue key studies on integration of gasifiers/gasification technologies with other conversion systems to determine the most optimum configurations and on identification of problems requiring R&D effort to resolve. ($173,000)

- o Continue to provide engineering analyses and systems evaluation capability for joint DOE/GRI Coal Gasification Program through monitoring processes, review of technical data and economic assessments. ($600,000)

- o Continue the "process development unit" effort exploring issues limiting the integration and development of gasifier/advanced hot gas cleanup systems/turbines for the production of power. ($0) (Prior year funding)

Environmental and Engineering Analysis ($1,131,000)

- o Continue the development of process modifications that will reduce the generation of trace hazardous compounds. ($375,000)

- o Complete the study of novel approaches to use microorganisms for removing trace amounts of organic contaminants in waste water. (Prior year funding) ($0)

- o Continue development of analytical models such that computer based systems analysis can be used to identify advanced gasifier systems--expand efforts to prepare environmental information for entry into the model. ($200,000)

- o Investigate new and novel methods for sampling and analyzing organics, sulfur species, nitrogen, trace elements, etc., and study ways to reduce toxicity of oils and tars. ($186,000)

- o Initiate comprehensive environmental sampling and analysis of systems employing hot gas cleanup systems. ($200,000)

- o Initiate the environmental assessment of those processes found suitable for production of new fuel forms. Make recommendations on areas of study needed to minimize the impact of those mild gasification processes that produce liquids derived from coal. ($170,000)

Great Plains ($437,000)

- o Continue management/monitoring of the Great Plains project as necessary. ($437,000)

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- PETROLEUM -

ADVANCED PROCESS TECHNOLOGY

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$5.4	$5.7	$5.5	$1.8	-67.3%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

There are two goals within the APT Program. These are: (1) to pursue the fundamental research relevant to oil, gas, and shale recovery, i.e., development of the tools and techniques to measure and predict important properties and phenomena, and to obtain the fundamental data critical to these recovery processes; and (2) to provide the proper environment to conduct research and to pursue application of new frontiers of science and/or as yet unexplored new concepts to achieve quantum increases in recovery efficiency for oil, gas, and shale resources.

The $1,811,000 requested for this activity would be used as follows:

Advanced Exploratory Research ($1,576,000)

- Continue fundamental petroleum, geoscience and chemistry research focusing on physical and chemical characterization studies of heavy oil; thermodynamic measurements; shale oil and tar sands bitumen studies and fuel storage and handling. Work will be performed by the National Institute for Petroleum and Energy Research. ($1,500,000)

- Continue extraction related aquifer contamination studies. ($76,000)

Arctic and Offshore Research ($235,000)

- Continue the Arctic/offshore oil and gas research data base. ($235,000)

ENHANCED OIL RECOVERY

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expense	$11.7	$11.9	$11.5	$4.5	-60.9%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of the Enhanced Oil Recovery (EOR) program is to conduct generic technology base R&D activities; develop fundamental knowledge that can lead to improved and new process concepts; and to assist industry in obtaining a better understanding of the mechanisms and behavior of advanced and novel EOR processes for the recovery of presently unrecoverable light oil, heavy oil and tar sand resources. In addition to specific funding listed below, technology programs in this area will be eligible for support through the industry cooperative R&D venture pool.

Funding requested in FY 1987 totals $4,484,000, applied as follows:

Heavy Oil ($608,000)

- Continue studies of steam additive mechanics and variables affecting mobility control and sweep efficiency. ($608,000)
- Complete remaining joint research with Venezuela and Mexico using previous EOR technical base funds. ($0)
- Complete, utilizing prior year funding, final report on variables in alkaline flooding in EOR. ($0)

Light Oil ($3,876,000)

- Investigate high temperature, stable polymer systems and continue fundamental surfactant studies. ($1,150,000)
- Complete post-field test analyses of EOR field tests and continue reduced studies of geologic heterogeneities and other characteristics on EOR process shortcomings. ($1,100,000)
- Continue environmental study of microbial EOR processes. ($100,000)
- Conduct basic multi-phase flow wettability studies to understand EOR process mechanisms. ($700,000)

- Continue studies of CO2 and other gas flooding concepts with emphasis on mobility control. ($826,000)

Tar Sands ($0)

- No funds requested.

OIL SHALE

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$14.6	$12.6	$12.1	$3.6	-70.2%
Deferral to Finance FY87	...	...	-2.9	...	...
Total	$14.6	$12.6	$ 9.2	$3.6	-60.9%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of the Oil Shale R&D program is to provide a sound technologic basis for reduction of economic and environmental constraints to industrial development of the U.S. oil shale resources and to increase the amount of resource that may be used economically. The program is focusing on basic research using reference shales to systematically study the chemistry, kinetics, and emissions related to eastern and western shale processing. In addition to the specific funding listed below, technology programs in this area will be eligible for support through the industry cooperative R&D venture pool.

The $3,595,000 requested for FY 1987 would be used to support the following research:

Oil Shale Technology Base ($3,078,000)

- Complete specific eastern shale research resulting from FY 1985 unsolicited proposals in the areas of hydroretorting and in situ processing. ($1,450,000)

- Continue developing a systems analysis capability to enable assessment from mining to spent shale disposal. ($277,000)

- Continue experiments with reference shales in various generic solids recycle retort systems to provide data for modifying and developing chemical, physical, and economic models. Maintain reference shale bank activities including characterization and distribution of shales to program participants. ($1,201,000)

- Continue development and maintenance of an oil shale data base. ($150,000)

Environmental Mitigation ($517,000)

- Continue development of the environmental data base. ($50,000)

- Identify and quantify major and trace element emissions in gases, liquids and solids from reference shales as a function of process parameters such as time, temperature, shale particle size and composition, and retort gas composition. Continue analytical methods development as necessary. Support environmental research and health and safety research under international agreement with Israel and interagency agreement with Bureau of Mines. ($467,000)

- GAS -

UNCONVENTIONAL GAS RECOVERY

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$10.1	$8.8	$8.5	$5.3	-37.6%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The specific objectives of the Unconventional Gas Recovery program are to: (1) reduce the uncertainty surrounding the potential magnitude of reserves of the unconventional gas resources and the conditions under which they will be produced; (2) develop and improve extraction technologies to the point of technical readiness for private sector development; and (3) transfer all technical and economic data to industry.

In addition to the specific funding listed below, technology programs in this area will be eligible for support through the industry cooperative R&D venture pool.

Eastern Gas Shales ($355,000)

- Continue development of the Eastern Gas Shale production technology base; also special geoscience investigations, system analyses, and technology transfer. ($355,000)

Western Tight Sands ($3,582,000)

- Conduct fracture stimulation research and production testing of remote lens at Multiwell Test facility. ($3,200,000)
- Continue supporting research modeling, systems analysis, and data base development. ($382,000)

Environmental and Advanced Research ($1,315,000)

- Continue resource identification and evaluation of gas hydrates and deep source gas. ($273,000)
- Continue lab analysis of hydrate core and modeling research. ($192,000)
- Conduct geochemical and geophysical diagnostic tests for gas hydrates on the North Slope of Alaska. ($650,000)
- Continue evaluation and development gas hydrate extraction/production techniques and data analysis of environmental assessments. ($200,000)

PROGRAM DIRECTION AND MANAGEMENT SUPPORT

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expense	$46.2	$55.3	$53.2	$40.2	-24.4%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

This activity provides funding for salaries, benefits and overhead expenses for the management of FE program at Headquarters, and the Energy Technology Centers:

The Headquarters staff is responsible for overall program direction which implements DOE policy and communicates that policy to the Energy Technology Centers, sets program objectives, develops program plans and evaluates alternative program strategies, develops and defends budget requests to the Office of Management and Budget and to the Congress, approves procurement plans, monitors work progress, evaluates projects, and approves revisions in work plans as required to attain program goals.

The Energy Technology Centers support day-to-day project management functions for assigned programmatic areas including contract and National Laboratory monitoring, development and maintenance of project budget, and procurement plans, and other activities related to program and site support.

The Office of the Federal Inspector for the Alaska Natural Gas Transportation System is responsible for coordinating all Federal activities pertaining to the pipeline in order to assure timely, efficient, safe, and environmentally sound construction including the assessment of developments in the world energy market, specifically the U.S. and Canadian oil and gas situation as they affect the Alaska Natural Gas Transportation System.

The $40,221,000 requested for FY 1987 would support the following activities:

Headquarters Program Direction ($11,260,000)

- Provide funds for salaries, benefits, and travel for Headquarters staff and overhead expenses generic to the entire FE program, including SBIR assessments. ($11,260,000)

ETC Program Direction ($28,740,000)

- Provide funds for ETC indirect costs and for site support. ($28,740,000)

Federal Inspector for the Alaska Natural Gas Transportation System ($221,000)

- Continue technical reviews of ANGTS design and/or remobilization packages. ($36,000)
- Complete long-term Frost Heave research using prior year funding. ($11,000)
- Continue development and refinement of Remobilization Encyclopedia. ($10,000)

- Continue to assess developments in U.S. and Canadian energy markets, and gas exploration and transportation projects in reference to ANGTS. ($33,000)

- Continue to maintain liaison with project sponsors, producers, other Government agencies, State of Alaska and Canadian Government. ($26,000)

- Salaries and related expenses for administrative and support functions. ($105,000)

COOPERATIVE R&D VENTURES POOL

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised	FY 1987	Percent Change from FY 1986
Operating Expense	$ ...	$ ...	$ ...	$12.5	+100.0%

The goals of the industry cooperative R&D venture pool are to increase the market relevance and penetration of federally funded applied R&D, to increase private sector leverage of federal funds, and to ensure that taxpayer-supported work in industry will benefit the industry and economy at large and not just a single company.

The vehicle for achieving this will be industry formed cooperative R&D ventures. The core of such ventures would be several private firms with at least two from the same industry (that is the distinction between a "cooperative venture" and a "joint venture"). The structure should, however, allow other parties such as investors, universities, institutes, and public laboratories to participate in the partnership as well.

The principal objectives of the program are to:

- Implement a process by which industry will join with Government in applied research and development activities that will result in products, processes, and technology that will contribute to achieving the energy and technology goals of the United States.

- Reduce and/or eliminate traditional barriers that have limited the financial and technical cooperation between the private and public sectors (e.g., patent positions, proprietary rights, anti-trust concerns, etc.).

- Identify a variety of incentives particularly suited to the needs of various venture partners.

In its FY 1987 budget proposal, the Department opted to limit the initial phase-in of the cooperative venture program to extraction technologies. In prior years, the Office of Fossil Energy has significantly increased the knowledge base for oil, gas and shale technologies. The nature of the economics of many of these technologies, coupled with the solid background of relevant industrial firms in participating in joint venture projects, makes extraction technologies prime candidates for an initial effort to examine the feasibility of the cooperative R&D venture pool approach.

The spectrum of efforts anticipated in these areas range from laboratory/bench scale activities through field tests -- precursors to actual commercial deployment and cash flow. The scale will vary from technology to technology and from resource to resource.

For example, many unconventional gas resources have not been defined well enough to develop predictable recovery strategies. Industry and other parties could form a cooperative venture with DOE to develop sufficient data requisite for the next step: design and test of promising recovery concepts. Similarly, in the area of underground coal gasification, primary interest could be focused on modest-scale, pre-commercial field tests to produce the data necessary for the subsequent design and construction of commercial plants. Additionally, interest may be expressed in the use of the technology in otherwise unattractive coals not currently being produced.

Therefore, in FY 1987, $12,500,000 will be made available to:

- Encourage the formation by industry of cooperative R&D ventures (which may also include other parties such as investors, universities, institutes and public laboratories) to offer partnership opportunities to DOE in the following areas: recovery of gas from unconventional sources; enhanced oil recovery; oil shale; and underground coal gasification. ($12,500,000)

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CLEAN COAL TECHNOLOGY PROGRAM

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1987	Percent Change from FY 1986
Operating Expense	$ ...	$99.4	$149.1	+50.0%

The principal goal of this program is, as stated in Public Law 99-190, "for the purposes of conducting cost-shared clean coal technology projects for the construction and operation of facilities to demonstrate the feasibility of future commercial operation." It is targeted at a wide variety of market applications.

Public Law 99-190 made available a total of $397.6 million for the Clean Coal Technology demonstration program (after the 0.6% general reduction applied across-the-board to programs contained in Public Law 99-190). Of these monies, $25 million will be held in reserve to cover the cost of overruns in the event the Government agrees to share such costs. Also, funds will be set aside for contracting, travel, and ancillary costs incurred by the Department of Energy in implementing the program. All of the remaining funds will be available for award. Under the terms of Public Law 99-190, the funds will become available in three increments as follows: $99.4 million in FY 1986, $149.1 million in FY87, and $149.1 million in FY88.

The Clean Coal Technology Program is related to, but not a direct continuation of, the effort undertaken by DOE following passage of Section 321, Public Law 98-473, 98 Stat. 1874. This section directed the Secretary of Energy to solicit "statements of interest in, and proposals for projects employing emerging clean coal technologies," and submit a report to Congress. In carrying out this Congressional request, DOE received 175 submissions with project values totaling more than $8 billion. On May 1, 1985, DOE submitted its findings in the Report to Congress on Emerging Clean Coal Technologies (NTIS Document Number: DE850154290). The Department also submitted a Supplemental Report to Congress on Emerging Clean Coal Technologies (NTIS Document Number: DE85018356) which further characterized a wide range of clean coal technologies.

Funds for the Clean Coal Technology program subsequently made available by Congress will provide for a competitive solicitation of project proposals and the award of cost-shared federal assistance to those projects that best demonstrate the feasibility of new clean coal technologies for future commercial applications. The issuance of the solicitation, receipt of proposals, and selection of projects will be made in accordance with the timetable established in Public Law 99-190. Specifically, the $149.1 million previously made available for FY 1987 will be used to:

- Support, on a cost shared basis with the private sector, demonstrations of advanced technologies to gather data needed for their ultimate commercialization. ($147,112,000)

- Provide for contractual services and in-house support in performing post award monitoring and technical data base activities. ($1,988,000)

The following page contains a table summarizing the FY 1985-FY 1987 funding for DOE's Fossil Energy research and development program. (The chart does not reflect funding made available for the Clean Coal Technology program since it represents previous appropriations.)

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Budget Authority in Thousands of Dollars)

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
COAL:			
Control Technology and Coal Preparation	$ 34,791	$ 31,950	$ 18,147
Advanced Research and Technology Development	30,804	33,849	27,224
Coal Liquefaction	31,110	31,620	9,147
Combustion Systems	30,092	29,113	9,169
Fuel Cells	40,472	34,057	5,000
Heat Engines and Heat Recovery	11,850	12,314	7,942
Underground Coal Gasification	5,705	4,072	---
Magnetohydrodynamics	30,721	27,717	---
Surface Coal Gasification	35,134	41,323	5,598
Subtotal, Coal	250,679	246,015	82,227
PETROLEUM:			
Advanced Process Technology	5,364	5,523	1,811
Enhanced Oil Recovery	11,702	11,454	4,484
Oil Shale	14,628	12,136	3,595
Subtotal, Petroleum	31,694	29,113	9,890
GAS:			
Unconventional Gas Recovery	10,142	8,503	5,252
Subtotal, Gas	10,142	8,503	5,252
POLICY AND MANAGEMENT:			
Headquarters Program Direction	8,273	13,380	11,260
ETC Program Direction	37,907	39,265	28,740
Federal Inspector for the Alaska Gas Pipeline	1,401	511	221
Capital Equipment	4,425	2,865	---
Construction	4,916	3,332	---
Subtotal, Policy and Management	56,922	59,353	40,221
COOPERATIVE VENTURE R&D POOLS	---	---	12,500
Subtotal, Fossil Energy	349,437	342,984	150,090
Use of Prior Year Balances and Other Adjustments	-60,389	-31,030	-67,323
Total, Fossil Energy R&D	$289,048	$311,954	$ 82,767

Senator DOMENICI. Thank you very much, Mr. Secretary.

Senator Ford, do you have any questions?

Senator FORD. Yes, Mr. Chairman, I do. I appreciate your allowing me to go first. I have another meeting to go to which is difficult for all of us. I feel very strongly for you in your position, the way you are being pulled and tugged.

Ms. Fitzpatrick, let me ask you two or three questions, and I have two or three questions for Mr. Bauer. You end your testimony, the full one you submitted to the committee, by saying, and I quote, "This is a budget which I believe seriously recognizes today's fiscal responsibilities as well as tomorrow's needs."

DOE's budget request for the entire Department exceeds their actual fiscal year 1986 appropriation, yet your request for energy conservation is a 91-percent cut from last year's appropriation. Is this a fair share for energy conservation to carry in light of the overall increase in your budget?

Miss FITZPATRICK. Senator Ford, it is true that there is a 91-percent cut in the total appropriation.

Senator FORD. So my figure is correct?

Miss FITZPATRICK. If you include the State grant programs which total about $250 million. So the bulk of the cut has come because we have not asked for funds for State grant programs. The reason for not doing that is that the States have just received, and we knew they would be receiving, $2.1 billion from an Exxon oil overcharge case which they are required by court order to apply to those same programs. In light of that funding to the States from that other source, we judged that it was not advisable to seek an appropriation for those grants.

Senator FORD. What are you going to do with the people in the Department who have been working on these programs? Will they be RIF'd?

Miss FITZPATRICK. No, we have requested funding for the people for two reasons: First, because we have outstanding Federal appropriations which must still be administered. The grants that have been appropriated from 1985 and 1986 will still need administration. Also, we have been working hard with the States on helping them to make better use of the funds they have received either from Federal or other sources in achieving energy conservation.

Senator FORD. Are you going to monitor the States' expenditure of Exxon's oil overcharge money?

Miss FITZPATRICK. The court order requires that the States send us an annual report on how they are using those funds.

Senator FORD. But you do not oversee anything?

Miss FITZPATRICK. Our ordinary monitoring process would be involved with the distribution of funds for the most part and also some detailed reports on it. So because the funds are going out through a different mechanism, we will not be engaged in that kind of monitoring.

Senator FORD. Will you be reporting to the court in any way?

Miss FITZPATRICK. Yes, I expect we will.

Senator FORD. Has the court ordered you to report to them?

Miss FITZPATRICK. The court did not explicitly order us to report to them.

Senator FORD. Why are you reporting, then?

Miss FITZPATRICK. What we have said is that if we find that there is something amiss in the States' use of the funds, then we expect that we would bring that to the attention of the court.

Senator FORD. In your noticing from the Hollifield table that DOE requested $213 million at the Assistant Secretary level for energy conservation and received $39.4 million as a budget request, apparently OMB does not think much of energy conservation.

Miss FITZPATRICK. Senator, I think the $213 million is not correct.

Senator FORD. It is not?

Miss FITZPATRICK. No.

Senator FORD. It is in the table that the Secretary sent up here.

Miss FITZPATRICK. I would have to look at those tables and see what is included in that figure, but I do not believe it is correct. I would like to provide for the record the accurate figures.

[The information follows:]

CONSERVATION BUDGET REQUEST

The $213 million figure refers to one of the levels that was considered in the Internal Review Budget process. The request that was actually provided to the Office of Management and Budget was $177 million for energy conservation programs. The Congressional Request was $39.4 million.

Senator FORD. How many people at OMB are on the energy conservation budget?

Miss FITZPATRICK. How many people does OMB have working on it?

Senator FORD. Yes; do you have any idea?

Miss FITZPATRICK. I think there are a couple of budget examiners and their supervisors.

Senator FORD. There is a lot of interest in this area at OMB.

Miss FITZPATRICK. I hear a lot from them, yes.

Senator FORD. Madam.

Miss FITZPATRICK. I hear a lot from them; yes.

Senator FORD. In a question and answer for the record last year you showed a list of countries and what they spent on R&D and industrial energy conservation. The list is in annualized American dollars at the exchange rate of January 1, 1985. The Federal Republic of Germany $10.2 million, France $12.4 million, Sweden $22.1 million, United Kingdom $28.1 million, United States $31.9 million.

Your answer for the record last year quoted a report which said, and I quote from your answer last year:

The search for high quality research and development was fueled by a growing recognition in all four countries that industrial energy conservation can increase industrial productivity.

Your budget request of $15.6 million, if adopted, would put the United States behind Sweden and the United Kingdom. Is that correct?

Miss FITZPATRICK. Yes; it would.

Senator FORD. Let us talk about deferrals. How much are you proposing to defer?

Miss FITZPATRICK. About $23 million from renewables and about $31 million from conservation.

Senator FORD. $57 million?

Miss FITZPATRICK. About $54 million.

Senator FORD. $54 million. How much of this was congressional add-ons?

Miss FITZPATRICK. Essentially all of it.

Senator FORD. All of it.

Miss FITZPATRICK. Yes.

Senator FORD. So whatever Congress wanted to do, you are going to defer?

Miss FITZPATRICK. The administration has had to make a decision about what is the most proper budget request, and we are remaining consistent in our recommendations of what should be done.

Senator FORD. Whatever Congress did shall go under, and whatever the administration has shall go on?

Miss FITZPATRICK. That is essentially our present position; yes, Senator.

Senator FORD. When do the deferrals go into effect?

Miss FITZPATRICK. They went into effect on our books when the President's budget request went up.

Senator FORD. Senator Wallop asked you a question, to respond to a depreciating assessment of the planning process in conservation and renewable energy programs at DOE. Criticism of the programs' management was leveled by former Under Secretary Pat Collins, and you responded to Senator Wallop—Wallop called Collins' assertions "pretty tough stuff," I quote from him, and asked you to respond to each of Collins' comments on conservation and renewable energy programs. Have you done that?

Miss FITZPATRICK. Yes, sir; I have.

Senator FORD. Is that available to the committee?

Miss FITZPATRICK. Yes, sir; I will most certainly make it available to you.

Senator FORD. Will you see that it is made available to us?

Miss FITZPATRICK. Yes, sir.

[The information follows:]

REVIEW OF "CONSERVATION AND RENEWABLE ENERGY, STATE AND LOCAL ASSISTANCE PROGRAMS, TECHNOLOGY PROGRAMS"

A report by W. Patrick Collins, former Under Secretary of the Department of Energy, entitled "Conservation Renewable Energy, State and Local Assistance Programs, Technology Programs," has been submitted to the Secretary. The following is a review of that report and CE's response to it.

The report is a critique of the way in which the Government activities in conservation and renewable energy research and grant programs have been established and maintained. It reviews the roles of the Department of Energy (DOE), the Congress, scientists in the private sector, universities, and Government laboratories, research contractors, industry, special interest groups, and public information media. The recurring theme is that, in one technology after another, sufficient information to make rational funding and research decisions has been lacking, insufficiently disseminated, or overridden by local or special interests. The solution offered is to establish mechanisms for the open sharing of information among all interested parties, so that Federal budget decisions can be made responsibly in the best interests of the Nation and long range research and development plans can be based on the most reliable information and opinions.

The second major theme of the report is the lack of sufficient expertise in the Government to transfer the results of Government funded research to the public. The report proposes that the Government should use electronic and print media to inform the public of the status of the various technologies, their availability for use, and Government policy in developing energy technologies.

Observations regarding DOE's planning processes in conservation and renewable energy research are accurate to the extent that they reflect conditions in 1983, when Mr. Collins came to the Department. The Administration had been submitting budget requests which would essentially shut down much of the research in the Office of Conservation and Renewable Energy (CE) and eliminate the conservation grant programs. In such a situation, CE was not motivated to undertake long range planning. Congress never accepted the proposed budgets and instead wrote its own, amounting to approximately $700 million per year. Appropriations hearings were acrimonious and the Department was not effectively participating in determining its own budget.

Under the direction of former Secretary Donald Hodel, with Mr. Collins's support, CE began in 1983 to analyze the technologies in the CE research programs to determine their potentials for increasing the efficiency of energy use (conservation) or supplying energy in a variety of forms from domestically available non-fossil, non-nuclear

resource (renewables). These analyses have resulted in the publication, beginning in 1984, of multiyear research and development plans, identifying critical research needs and the proper role of Federal activities. The process is by its nature a continuing one and the level of participation by interested parties outside of DOE has been increasing and will continue to do so.

As an example of the effort to expand participation in the planning process, the National Research Council of the National Academy of Sciences held a symposium on the conservation multiyear plan, at the request of the Department. The two day meeting in December, 1985, included participants from academia, industry, professional societies, Congressional committee staffs and the Congressional Research Service, the Energy Research Advisory Board, the national laboratories, and several foreign countries, including the Commission of the European Communities. The formal report is not yet available, but the comments given at the symposium were highly favorable to the plan.

In 1986, CE will place greater emphasis on involving the national laboratories in task force reviews to determine overall priorities in national laboratory activities.

The issue of how best to transfer the results of Federal research has been addressed at the level of the individual technology programs. The great bulk of information generated by CE research is highly technical, due to the emphasis on basic and early applied research. The audience for this information is generally other researchers in national, university, and industry laboratories. Therefore, the most appropriate means for transferring most of the information is through targeted program reviews, seminars, professional conferences, and publications. Some information is useful for a wider audience or the general public and the Department uses a variety of dissemination techniques, including the National Appropriate Technology Assistance Service, the Conservation and Renewable Energy Information and Referral Service, the Technology Information Center, and energy information offices in the States and Territories.

CE is maintaining its emphasis on effective technology transfer through the research program offices and views the entire research and development process as an integrated whole, requiring the involvement of all private and public sector participants from the earliest planning to the final transfer of Government funded research results. In 1985, a technology applications division was established to coordinate and focus the technology transfer efforts that are already part of every research program in CE. In addition, we are placing more emphasis on technical assistance and technology transfer in our state and local assistance programs.

There have been activities in several of the other areas of concern to Mr. Collins. Mr. Collins recommends encouragement of private efforts in low-income weatherization. We have recently initiated a 5-state pilot project to assess the capability of states to stimulate private and non-Federal support of low-income residential retrofitting. An innovative financing initiative was undertaken in response to the need

to develop ways of supplementing Federal weatherization funds. Models demonstrating shared savings, bank participation, and energy services company business development are being concluded. New models testing hybrids of these initial shared savings approaches are underway.

CE will continue to expand the opportunities for participation in the research planning process. The reviews of the National Academy of Sciences and the Energy Research Advisory Board will be continued.

CE will continue emphasis on maximum interaction with industry in both planning research and applying results, including investigating novel cooperative venture possibilities to help leverage available resources and assure the utility of research programs, and will remain alert for opportunities to transfer useful information to new audiences, such as least-cost planning for the utility industry.

Senator FORD. I am hoping that your budget will not fly, but what has happened in the last 5 years, and I say this with all due respect, is that I have had them sit at that table and say whatever you put on the budget, whatever you add to it, we are not going to spend it. Whatever you do to the budget, if it does not agree with ours we are not going to spend it.

So I think you are good to your word. I do not doubt that at all. You have deferred everything that Congress thought was appropriate, and so if they add it on you are not going to spend it. That is even tougher than when I was Governor. [Laughter.]

Senator FORD. Mr. Bauer, you said on page 1 of your statement:

> But perhaps most importantly, by reflecting this Administration's commitment to fiscal restraint, the fiscal year 1987 Fossil Energy budget request will do its fair share in helping to bring Federal spending under control and removing the last remaining obstacle to a future of continued economic growth.

I just wondered how you could make a statement like that when the total DOE departmental budget request is in excess of 1986 appropriations.

Mr. BAUER. Senator Ford, in taking a look at the fossil energy R&D budget by itself for just a moment, and yes, I recognize that there are deferrals in there.

Senator FORD. It is down 73 percent. Somebody else is getting all that you are giving up and then some.

Mr. BAUER. Fossil energy's budget authority last year was $342.9 million.

Senator FORD. Seventy-three percent.

Mr. BAUER. That is about right. But when we look at the technologies that we are pursuing and the current status of some of those technologies and also efforts that are currently being completed, what we did was attempt to properly balance the fossil energy budget.

For example, in fiscal year 1987 we have met the commitments on TVA. We have made the final payment on kilngas. There are some technologies that we believe, need additional technology development work that needs to be done and yet it is very expensive and long term. MHD is considered technically OK but unaffordable at these times.

Also, on fuel cells, we are proceeding along on the 11 megawatt configuration A with UTC on prior year funds. There were some fiscal year 1985 funds that we are using to develop configuration B.

For the record, Mr. Chairman, two of the deferrals are now rescissions. One of those is the 7.5 megawatt fuel cell with Westinghouse. There is competition on some of the other fuel cells. We are reaching a point on internal reforming versus external reforming and propcsing to go competitive on those two technologies.

There are other technologies where we believe that sufficient data exists. Take Wilsonville, the pilot plant where we do direct liquefaction research. We have tested three coals at all different kinds of temperatures and pressures and recently, we had a very good—I think it was a 30- or 40-day run in the closed couple mode. We are getting more distillate per pound of coal than we did out of our previous direct liquefaction processes that we worked on.

So we believe there is sufficient data there for the marketplace to make a decision. We have gone through and looked at those technologies and also taken a look at what we are doing on the acid rain-related research for which we are getting significant cost sharing. There are a lot of good technology programs there.

But for those that Congress added, those ongoing programs are continuing until the date, as Ms. Fitzpatrick mentioned, from the date of the submission of the budget to March 20, and we have not taken any precipitous action.

Senator FORD. Well, Senator McClure, who is chairman of this committee, and Senator Byrd signed a letter to DOE asking them not to put the deferrals into place until Congress has a chance to act.

Do you think DOE will accede to this congressional request? I believe you had Representative Yates and another Congressman who both requested that you defer it.

Mr. BAUER. Senator Ford, I believe the letter has come back up from the Secretary saying that he will revisit it upon good indication from Congress and that there will be a positive action on the deferrals.

Senator FORD. Which way? [Laughter.]

Mr. Chairman, I have a couple of things I would like to ask about, Great Plains, and naval petroleum reserve. One last question, and I appreciate the time you have given me.

Mr. Bauer, last year you requested $242.7 million in program authority for fossil energy. Your budget submission last year said, and I quote, "The Department's fossil energy program is geared toward establishing an adequate scientific and engineering knowledge base to support private sector efforts to develop and deploy these technologies. The proposed 1986 budget is a balanced budget which addresses these needs and focuses on long-term, high risk research and development activities which might not otherwise attract sufficient private sector investment."

This year you are requesting a 40-percent cut from what you said last year was necessary for an adequate scientific and engineering knowledge base. Logically, if as you said in your 1987 budget request for fossil is its fair share, it nevertheless must be inadequate then to sustain the knowledge base. Am I right on that?

Mr. BAUER. You are correct, Senator Ford.

Senator FORD. I am through, Mr. Chairman. Thank you.

Senator DOMENICI. Thank you, Senator Ford. Senator Evans.

Senator EVANS. Thank you, Mr. Chairman. I would like to follow through on some of the concerns and questions about deferrals, and I am not sure whether we are getting into budgetary rather than program matters, and I am not sure that these questions should be addressed to either of you as much as to our chairman, but let me see if I can give it a try, and I will end up understanding a little better.

Do you have your budget person from the Department with you?

Mr. BAUER. I do not.

Miss FITZPATRICK. No, sir.

Senator EVANS. Fortunately for him. [Laughter.]

Ms. FITZPATRICK. It is a lady, Senator.

Mr. BAUER. It is a lady.

Senator EVANS. Even more fortunate for her.

Mr. Chairman, let me ask you a question.

Senator DOMENICI. She is busy deferring. [Laughter]

Senator EVANS. That is what I wanted to ask about. It is my understanding that deferrals, unless they are for multiyear obligations, are deferrals that are for a specified period of time within a fiscal year but ultimately the money should be released so it can be spent out at an adequate rate before the end of that fiscal year. Is that essentially correct?

Senator DOMENICI. Frankly, I regret to tell you that I do not know.

Senator EVANS. Well, I went back to try and do some—now I guess the real question is: What is a deferral? Is a deferral just an opportunity? Maybe I should ask the Department or Secretary Fitzpatrick.

In your view, is a deferral just a decision not to spend? Or is it a decision to defer for a short period of time to associate spend-out rates with the number of months left in the fiscal year?

Miss FITZPATRICK. Senator, I do not want to be in a position of knowing more than the chairman knows. [Laughter.]

Senator DOMENICI. Frankly, I think the word "deferral" only refers to the statute which contemplated "some further" action; consequently, they were deferred for a period of time until the action was taken. The action that was expected was action by the Congress.

But it appears to me that with the *Chadha* case that it is effectively an elimination of the program unless you can get both Houses of Congress to overturn the deferral in a joint-type resolution which would be signed by the President and thus become law. So it effectively eliminates the program for the year, because there is no way that that can be done.

I would assume maybe you might if you had an appropriation bill running through here which had some leverage in it, you might overturn after deferrals and give the President aid for Nicaragua or something, and then he would sign it, and it would effectively overturn in a temporary nature, but I assume everyone is acting as if they are completed because there is no way, short of concurrence with the White House or putting it in some bill that they will sign. It is going to effectively turn into a rescission as if the rescission was effective.

Now if some of the staff thinks to the contrary they can tell me, but I think that is what it is.

Senator EVANS. That is my concern.

Senator DOMENICI. They do not expect to have it back on board from what I understand. Is that about right? You are assuming it is gone, the deferred items, are you not?

Miss FITZPATRICK. Yes, Mr. Chairman.

Senator EVANS. So for all practical purposes, the only difference between a deferral and a rescission as far as the Department is concerned is that one requires congressional approval and the other one does not. Is that essentially correct?

Miss FITZPATRICK. That seems to be the practical effect, yes.

Senator EVANS. Mr. Chairman, I think if that course is broken down, we had better fix it up——

Senator DOMENICI. It is.

Senator EVANS [continuing]. And fix it up pretty quickly, because Senator Ford went through and elicited from a previous hearing the same testimony, that essentially all the deferrals represented the add-ons that Congress made.

In fact my next question was: In other words you want to act as if the congressional budget process never occurred and the administration continues to spend on the basis of its own priorities without any attention whatsoever to what Congress does in terms of new initiatives or changed priorities. The answer before was yes.

I am pretty distressed if that is the case here in our energy conservation budget. I think it is a very important one.

Senator DOMENICI. They did slightly better than that. The Department found that out of $1.625 billion that they asked for and got, they were wrong on $3.9 million and we were wrong on all the rest. So I did not get the percent, but they have an enviable record for being right. We have a disastrous record, obviously, for not being right.

Senator EVANS. Pure as Ivory Soap, 99 and 44/100ths.

Senator DOMENICI. We are wrong most of the time.

Senator EVANS. It is a deep concern. I do not know why, Mr. Chairman, why we even go through the process of oversight and the process of trying to do budgeting when it makes no difference. Either that, or we are going to have to figure out a way to make it make a difference. Maybe a way to make it make a difference is, as I suggested at the last hearing, was to pay all of the managers of all of the programs a percentage salary that depends on the spend-out rates. For every deferral there would be a cut in salary, so that maybe we would get some action that way, somehow.

Otherwise, what difference does it make that we go through these hearings if the end result is that no attention is paid to them?

Senator DOMENICI. Frankly, I have about 20 questions for each, but I really do not believe I will ask them. I will submit them to them and they can answer them.

But I really think you might pass on, on behalf of at least one Senator, that he is pretty much a pragmatist and that probably one might have concluded that 40 or 50 percent of the add-ons—I will be overly critical of ourselves and say that they might have had parochial input, or they might have been vested with some notion that we have more money to spend than we really do—but I really think that deferrals of this magnitude in terms of numbers would have slightly more credibility if they were spread out a little bit among programs that you all put in your budget, too. We know how you do them.

I mean, fully half of them are done by OMB and half are done by you all. I think you could have at least, in the quiet of your deferring, given more credit to yours and less to theirs. Then we could have asked you, and you would have had some way to explain it a little bit. If I am being overly tough, excuse me. I just go through this myself all the time from every side.

In any event frankly I do not see any reason to ask why all of these programs were deferred, because basically what I would prefer to do if I had time, and I do not, is to go back through the

$1.6 billion in this area that you all submitted and find out what consideration was given to deferring some of those. I think that would make it a lot more valid exercise, but I will not do that.

Senator EVANS. Mr. Chairman, let me go beyond just my overall concern with a couple of specific questions.

First, the statement was made, I think by at least Mr. Bauer and maybe by both, that the Gramm-Rudman-Hollings limits and our response to those limits are what caused the budget to come in as it did. I think that is the biggest misunderstanding I know of as it relates to Gramm-Rudman-Hollings.

There are no limits. There are no limits whatsoever except that the budget must produce a deficit of no larger than $144 billion at the end of fiscal year 1987. There are no limits on spending. There are no limits on taxing. There are no limits on priority.

It seems to me that what the administration is saying now with this particular program, the combination of deferrals and the program as you look ahead toward fiscal year 1987 is that energy research and development on conservation is pretty low on the totem pole and it is not very necessary. Is that an accurate statement?

Miss FITZPATRICK. Based on the budget figures, Senator, yes, it is.

Senator EVANS. I do not know if this is an internal affair or whether you feel you can answer it. Did the Department, in submitting its budget to OMB, request all these deferrals? Or was this OMB's idea?

Senator DOMENICI. I did not hear the question, Senator.

Senator EVANS. I said, were the deferral requests for all of these deferrals submitted by the Department to OMB, or was this all OMB's idea?

Miss FITZPATRICK. You have the Hollifield table, Senator. The deferrals were not a part of our request to OMB.

Senator EVANS. So it is not your view of the priorities of this particular field?

Miss FITZPATRICK. Not at the time we submitted the request, which was sometime last summer, around August.

Senator EVANS. In your testimony, Secretary Fitzpatrick, in a number of areas you mentioned the hope, I guess, or the ability to move research off to combined efforts with private enterprise or research by others.

Why suddenly now do something like this? What is different about circumstances now as opposed to 1 year ago or 2 years ago or 5 years ago that makes this any more valid?

Miss FITZPATRICK. Senator, I do not think it is a sudden effort on our part, because we have for several years been emphasizing very strongly cooperative research with industry in the sense that we have asked them to work with us from the very beginning of our planning process, and our research contracts with industry are cost-shared as a matter of course.

What we are proposing is that we develop a new tool in achieving these same goals of leveraging Federal funding, of having industry participate in the setting of priorities, and having mechanisms which will encourage and enhance technology transfer.

Senator EVANS. Does that extend to joint research—how does that same theme work in terms of research and development carried on by private laboratories and by universities and colleges?

Miss FITZPATRICK. The particular mechanism which is an R&D cooperative venture requiring equity input by the non-Federal partners as well as the Government would not apply there very well to a university laboratory because they generally do not have the resources to do that. In fact, with our research contracts with university laboratories, we rarely ask for cost-sharing, at least monetary cost-sharing. Sometimes we do for planning and personnel.

So I would not envision that university laboratories would engage in this kind of cooperative research. Some private laboratories in the country that we have been very active with might find that they would want to do this.

Senator EVANS. Even if this is basically a partnership with private enterprise, are not their interests really in the energy—you know, if all of research and development is sort of on a continuum from pure research over here to actual prototype on the other side, is not their interest really closer to the prototype side of things?

Miss FITZPATRICK. Yes, it could tend to be. That is why we are only suggesting this as another tool that we use to address that entire spectrum of research needs.

Senator EVANS. Do you feel that with the deferrals made, are we doing an adequate job of producing the research at the Federal level, producing money for the research at the Federal level, in basic research in the beginning that has to happen before you get to any interest in the partnership program to secure our energy future?

Miss FITZPATRICK. Senator, I think that the budget request protects the basic interests and goals of each of the technology areas. What we have done is to try to narrow the focus and choose the highest priority prospects. That means that we will not be doing some things which we felt showed promise and were worth pursuing but we do not have the resources for.

What it means is, as a practical——

Senator EVANS. Let me just interrupt and correct right there. You could get the resources for it if you asked for them possibly, and you chose not to ask for them.

Miss FITZPATRICK. There is a balancing, that is true. There is a balancing of interests and of needs that goes on, and with what we had available, we have made the best choices that we think we could.

Senator EVANS. Did you have a chance to reprogram after the OMB came back with the deferrals and their suggestions for cutbacks? Did you have a chance to reprogram what was left?

Miss FITZPATRICK. Within the budget limits that we had, we assigned what was to be done with the money.

Senator EVANS. Did OMB carry on the deferrals in some very specific programs?

Miss FITZPATRICK. That is true.

Senator EVANS. Did you accept those and decide that was an appropriate new level for each of those R&D programs, or did you reprogram or change some of those afterward within the total amount of money remaining because you had a different idea of priorities than they did?

Miss FITZPATRICK. We were allowed a very small discretion in where the deferrals would come from.

Senator EVANS. Would you say essentially none?

Miss FITZPATRICK. Very close.

Senator EVANS. One other question, Mr. Chairman. In the use of the Exxon money, how do you justify the allocation of money in that way, given the wording of the Warner amendment which I think clearly says this money will be used to supplement and not supplant. I think those are the two words used.

It just seems to me to be so clear that you have supplanted. How can you justify that, given the law?

Miss FITZPATRICK. Senator, the Warner amendment says that the Governors shall use the money to supplement, not supplant, funds which may otherwise be made available. So what we are saying is that it is not necessary to make funds otherwise available.

Senator EVANS. Well, I am looking around to see whether the Mad Hatter is in the room. [Laughter.]

I am afraid I cannot buy that logic, if there is any, there. This is money that was—I understand what you are trying to say as closely as I can follow it, that a certain amount of money in one of these five programs was made available last year through fiscal year 1986 through the Federal Government, and it goes to the States for use in this low-income energy program.

But now with the Exxon money, that will be distributed in those States, but it will be supplementary because you will take away this money so that it will be supplementary to zero. Is that essentially it?

Miss FITZPATRICK. Yes, sir.

Senator DOMENICI. Before I yield to Senator Hecht, I have some Mexicans waiting for me, Senator Evans, and I would hope you would chair for me.

Senator EVANS. I would be delighted to.

Senator DOMENICI. I do have a couple of questions.

First let me for the record clarify the deferral statement I made because I am sure it was right, but I am not sure that I made it understandable.

The concept in the Budget and Recombinant Act is deferrals as compared with recessions. The deferral was to be overturned, if it was going to be overturned, by one House of Congress within the timeframe stated in the Budget and Recombinant Act, so that you would defer for *X* number of days as prescribed by statute, and the work is very descriptive.

Nothing happened. It was just held in abeyance for that period of time. Then one House would act to overturn the deferral and it would then be back on the books and the budget authority would be operative as if never adversely affected.

The *Chadha* case said that that is unconstitutional for one House of Congress to do that. So what we now have is we have the act there but we do not have a mechanism for overturning the deferral because the prescribed mechanism has been declared to have shortcomings constitutionally. So it is now presumed by the administration that deferrals still exist, which is now in Court. Yet they may not exist.

You may have these all back on the books by order of the Court because the Court could very easily rule that since the mechanism for overturning is gone, the operative mechanism for doing it is

gone. That is a 50–50 call from what I can tell as a lawyer. They could very well do that.

On the other hand, Congress is sitting now saying: One way to overturn deferral, we do not even see the deferral act. It is for both Houses of Congress to pass a joint resolution overturning the deferral.

But it is clear from the language of the *Chadha* case that that is a bill, that is equivalent to a bill that would have to be signed by the President in order to be effective. So you are pretty safe for now in assuming they are gone, because we cannot get them back on without something that is passed by both Houses and signed. And we are in an interesting bind because to the extent we would like to send all that up to the President, if we pick and choose, I assume we will agree with you on half and not on the other half.

We have to put that in some kind of appropriation measure. And we are bound by the ceilings that we now have under Gramm-Rudman-Hollings and we have to find some other savings; so we are caught in that kind of a bind.

So I think that is the current status of things. Why did it not happen earlier with *Chadha* having been in existence for, what, 20-some months? About how old is *Chadha*; 2 years? I think the reason we did not have the problem was that this was clearly understood by the administration last year as being a very unsavory, to use a mild word, situation fraught with danger on all sides and, consequently, deferrals were used very sparingly by agreement with then-OBM Director Stockman and the appropriators on both sides.

I am not now suggesting that they are being used unsparingly. It would appear to me that they are, but I have not looked at the whole package. Maybe this is still sparingly and with some kind of consideration for the fact that Congress is in this intermediary bind under the law.

In any event, that is about where we are. I have just two questions. I am kind of intrigued that sometime after the deferrals, $38.5 million of deferrals were changed into rescissions. I assume you are aware of that?

Miss FITZPATRICK. Yes, Mr. Chairman.

Senator DOMENICI. That is the National Center for Chemical Research, Columbia University; Demonstration Centers for Information Technology, Brown University; Advanced Science Center, University of Oregon; Energy and Mineral Research Center, University of Alabama; et cetera.

Do you have any information as to why these achieve such an instant sort of exceptional status among university programs, Madam Secretary?

Miss FITZPATRICK. Mr. Chairman, those items are not in my budget, so I was not involved in any of the discussions on them.

I am glad you do not have to discuss it. Frankly, you are too nice to beat up on. [Laughter.]

Senator DOMENICI. I assume that you have looked into that poor little New Mexico University, one which did not receive such high status, the Southwestern Residential Demonstration Program? At least I gave you a little advance notice on that. I do not imagine you are able to compare its validity in the spectrum of things with

this 38.5. So maybe you could just tell me why it was deferred and not granted some other status.

Miss FITZPATRICK. Mr. Chairman, that is a photovoltaic residential experiment station.

Senator DOMENICI. Yes.

Miss FITZPATRICK. It is one of several around the country that have been maintained for several years. We have felt for some time that they have served their purpose very nicely. The private sector is now picking up on such systems, not just experimentation but actual installation and it is time to phase those out.

Senator DOMENICI. Do you think you might have, in the generosity of your heart, found that since it was judged the best in the country that you might have rescinded it and thus we could have kept it?

You could have, but you did not; is that the answer?

Miss FITZPATRICK. I was not allowed to have very much kindness this year, Mr. Chairman.

Senator DOMENICI. I see. Right.

I asked you about one other thing I think the last time you were before the Appropriations Committee. Congress appropriated $2 million additional for expanded effort in electrochemical research for fuel cells. You are not going to do that. Do you know why?

Miss FITZPATRICK. I am informed that we are doing that, Mr. Chairman.

Senator DOMENICI. You are? Was I mistaken, and you have changed your mind? Or was that never going to be terminated?

Miss FITZPATRICK. I do not think that we had planned to terminate that, Mr. Chairman. I do not think it was included in the deferrals.

Senator DOMENICI. We will not say you changed your mind. We were misinformed.

Senator Hecht, did you have any questions?

Senator HECHT. Thank you, Mr. Chairman.

First of all, I have an opening statement. I am sorry. I was detained on getting here.

Senator DOMENICI. Do you want to give it or make it part of the record?

Senator HECHT. We will just make it part of the record.

Senator DOMENICI. It will be made a part of the record.

Senator HECHT. Unless you want to hear a good speech. [Laughter.]

[The prepared statement of Senator Hecht follows:]

STATEMENT OF HON. CHIC HECHT, A U.S. SENATOR FROM THE STATE OF NEVADA

Mr. Chairman, I wish to commend the subcommittee for holding this hearing today on what I believe is a very important matter—the budgets for the solar, geothermal and conservation programs of the Department of Energy.

In these days of huge federal budget deficits, we must of course closely examine all federal programs for ways to cut expenses. Right now, with the price of oil so dramatically lower than just a few weeks ago, it may be tempting for us to cut the budgets of solar, geothermal and conservation programs.

However, I hope we all realize the price of oil will eventually rise again, perhaps sooner then many people think. We cannot count on cheap oil, and we cannot count on imported oil if we are to protect our national security. In the long run, we will need the type of safe, clean renewable domestic energy resources provided by solar, geothermal, and conservation.

As the Congress considers the President's budget for renewable energy, I hope we will all realize that promoting this type of domestic energy resource serves a national defense purpose, as well as a longterm economic purpose.

In this context, I am particularly concerned that we not jeopardize our future national energy security by cutting too deeply into the budgets of these programs, just because the short term outlook for oil prices seems reassuring.

Thank you, Mr. Chairman.

Senator HECHT. One fast question for Secretary Fitzpatrick.

The budget request for geothermal energy eliminates one activity and includes deep cuts in two activities. However, there is a small increase in program direction. What is program direction and why is it getting increased when the other geothermal activities will receive deep cuts?

Miss FITZPATRICK. The program direction is a line item for people; it is a case for staffing. I would like to provide for the record the explanation for the increase.

Senator HECHT. Please do, and I would like to hear from you.

[The information follows:]

GEOTHERMAL PROGRAM DIRECTION

As a result of reductions in geothermal program activities, the geothermal staffing was reduced by three Full-Time-Equivalents (FTEs) in FY 1987; however, the FTE funding requirements were repriced to be more consistent with actual funding needs. This resulted in an increase in program direction dollars even though the actual number of FTEs decreased by three.

Miss FITZPATRICK. Thank you.

Senator HECHT. Thank you very much.

Senator EVANS [presiding]. I could not let this opportunity pass without asking one more question about energy and conservation. Well, first, do you feel that the current plunge in oil prices and the free flow of oil that is now occurring is likely to continue over any extended period of time?

Miss FITZPATRICK. If I knew—Senator, I am very often asked to predict what the price of oil will be and——

Senator EVANS. Let me put it this way: Do you think it would be useful for us at this time while there is apparently an abundance of oil at very low prices to prepare for the potential of a oil shortage and getting ready for higher prices?

Miss FITZPATRICK. I do because I think that what the Federal Government has to do is to think of the long term: 5, 10, 15, 20 years. I notice the chairman very correctly observed that we as a country often act on a very short-term basis and have a short attention span, and I think it is the role of the Federal Government to have the long term in view.

Certainly over the long term oil prices will have to go back up. I do not think we should be deterred from our basic goals by what is necessarily a blip on the oil prices.

Senator EVANS. If I remember general figures, at least, we are headed in a direction where the amount of imported oil to the United States is now heading back up again from a decline that we saw for the last several years and that it is expected to be several times the current level within relatively few years, the amount of imported oil, and that currently I think something close to two-thirds of the known world reserves of oil are either under Commu-

nist or OPEC countries. Are those essentially accurate facts, as far as you understand them?

Miss FITZPATRICK. Yes.

Senator EVANS. That being the case, it would not take much disruption or collective decisionmaking at a time when it could count for both oil prices to shoot up and potentially for us to get into a severe shortage of oil. Is that also a very real potential?

Miss FITZPATRICK. Yes, Senator. I think the potential is certainly there.

Senator EVANS. With all that, do you think it's wise for the Federal Government to lower the fuel efficiency standards that were placed on automobiles 10 years ago?

Miss FITZPATRICK. There is a great deal of debate about how effective those fuel efficiency standards have been as standards. That is, would the market have done that anyway? Is there more drag on the market by imposing the regulations or not? I think it is a highly debatable issue and I am glad that I did not have to make the decision. That is the responsibility of the Department of Transportation.

I think that again the transportation market, in particular automobiles, is one of the markets that is susceptible to short-term changes or expected changes in oil prices. It is also susceptible to being turned around very rapidly, in case it is necessary to do so.

Senator EVANS. Turn it around very fast in what way?

Miss FITZPATRICK. As an example, we saw how quickly we had a swing toward the demand for more efficient automobiles in the mid-1970's when the prices went up.

Senator EVANS. We had the demand for more fuel-efficient automobiles and we did not have them.

Miss FITZPATRICK. That is true, and it was very vulnerable to foreign competition. I think what has happened is that the U.S. auto makers certainly know how to make fuel-efficient cars and they make fuel-efficient cars, but their product mix right now is responding to a demand that is pushing a bit toward the less fuel-efficient cars. But at least they have the tooling and the capacity to make more efficient cars and to change their mix rather rapidly.

Senator EVANS. You would say that most of those really fuel-efficient cars that are in the American automobile mix are made overseas?

Miss FITZPATRICK. I do not know the answer to that, Senator.

Senator HECHT. Would you submit for the record what I asked you to before and would you also put in your reason for cuts in the program on geothermal?

Miss FITZPATRICK. On the geothermal program, yes I will, Senator.

[The information follows:]

REDUCTIONS IN THE GEOTHERMAL PROGRAM

The geothermal energy program has been reduced in part by the orderly conclusion of a number of large engineering development projects initiated in prior years. The technical progress of the geothermal program has been paralleled by an increasing confidence in and commitment to geothermal technology by the private sector. This commitment and confidence is reflected in the development of a group of many small businesses and the creation of sizable divisions of large companies. Utilities, institutions, and states have become increasingly involved with promoting

and conducting research and development programs to further advance geothermal technology. Federal funding has been reduced in those areas where considerable interest has been shown by nongovernment entities. Federal dollars have been focused on the highest priority research to address the most critical technology base issues which have the greatest relevance and potential for future private sector development.

Senator HECHT. Thank you.

Senator DOMENICI [presiding]. Senator Evans, might you permit me to first thank you for agreeing to continue these hearings. We are obviously about to finish with the Department's witnesses and then we will have the non-Department witnesses.

I want to thank them for coming. I want to assure you that Senator Evans will take your testimony and we will obviously pay attention to your concerns as best we can. I thank you all very much for being patient.

And to the two secretaries who are here, thank you very much. You do a marvelous job under very adverse circumstances, and we try to do the same.

Miss FITZPATRICK. Thank you, Mr. Chairman.

Mr. BAUER. Thank you, Mr. Chairman.

Senator EVANS [presiding]. Thank you.

I think we will have some other questions; I know some other Senators will, as well. And to perhaps both of you and we would be delighted to have the answers.

Our next panel is Dr. Lloyd Lawrence, vice president, Mechanical Technology, Inc.; Dr. Stuart Ridgeway, R&D Associates—Dr. Lawrence was from New York; Dr. Ridgeway is from Marina del Ray, CA; and Mr. Vladimir Bazjanac, from Berkeley, CA. If you three would please come to the podium.

Welcome, gentlemen, to the committee. Mr. Lawrence, you are first on the list. If each of you would summarize your testimony, I will say at this time that the full testimony of each of you will be included in the record.

STATEMENT OF DR. L.R. LAWRENCE, JR., VICE PRESIDENT, TECHNOLOGY DEVELOPMENT, MECHANICAL TECHNOLOGY, INC.

Dr. LLOYD LAWRENCE. Thank you, Mr. Chairman.

I am Bob Lawrence, and I am vice president of technology development with MTI. We are a $60 million corporation and we have a firm of about 850 people specializing in high technology products and services.

I am here today to discuss the need for a strengthened DOE conservation technology budget, especially in the areas of gas-fired heat pumps, industrial R&D, and Stirling engines. I would like to point out to maybe amplify on the thoughts of Congresswoman Schneider earlier today that these things are not only just energy-conserving technologies but, in fact, they provide a commercial technology base that will aid our country in our international competitiveness.

I have quoted in my testimony some of the results from the President's Commission on Industrial Competitiveness, and in fact was taken directly from their final report entitled "Global Competition: The New Reality." The technologies, then, from the conservation budget apply directly to the kinds of recommendations that

this particular Commission made. I think it is important to point out then that the results of these programs are much more far-reaching than simply conserving energy at this time.

Moving along to the specifics of my testimony, gas and oil-fired heat pumps is one particular technology that can have a very broad range of application in this country. If you look at the fact that we have 50 million homes now heated by gaseous fuel and another 15 million heated by oil or kerosene, if you take those in the very gross sense—take the total number of homes and assume that a gas or oil-fired heat pump is going to be installed at a cost of approximately $4,000 per home, you are talking about a market of $260 billion. That is a fairly substantial market. And, unfortunately, our markets are still a good 3 years away from that market, which means the private sector has not yet stepped up to them.

Again, unfortunately, our Japanese friends have been a little more foresighted and in January of this year, the Japanese delivered 12 gas heat pump units to the United States to begin field and market testing. They are very aware of the size of this market and the kinds of employment that can be resulting from manufacturing products into this market.

Now it is our position that the American prototypes in the number of contractor laboratories can actually beat the Japanese competition because performance will be higher and costs will be lower. But, again, they are further away from the market. The Japanese have taken the approach of coming to the marketplace with rather rudimentary units to establish their distribution, marketing, and transportation channels and to get their servicing in place, and then follow that later with better units.

So it is our position, Mr. Chairman that if, in fact, 20 million per year for the next 3 years could be applied to this particular technology in a combination of private sector and government dollars, that in fact the American prototypes can be brought to the marketplace and we can win one for a change; it would be a nice change.

In the industrial programs, I just want to mention very briefly that these programs have now come to the point where they have actually paid back to the country, through the implementation of their technologies, more than was ever appropriated in total to support these programs.

The results that we are seeing are really based on the kinds of programs that were originally implemented in the late 1970's and 1980 and 1981, which are aimed at the 3- to 10-year timeframe, which no other budgets in the country seem to be addressing in the commercial sector.

Unfortunately, these programs are being more and more pushed out into the future and being looked at for much more long-term higher risk, which means that their effectiveness is going to be reduced in this time of rather dramatic budget deficits and balance of trade deficits.

I would strongly encourage the subcommittee to put language in the bill along with restoring these programs to the level they ought to be at, put language in the bill, saying that they should return to the 3- to 10-year timeframe to be addressing that.

Finally, Mr. Chairman, I am happy to report that our automotive Stirling engine program continues with a great deal of success.

And for 4 years in a row now we have been rated outstanding in every single category in every evaluation that NASA has made on this program. As you know, it is once every 6 months.

In the past year, we have gotten industrial interests to the point where John Deere has cost-shared approximately 25 percent of the part of the program they are now involved with, manufacturing Mod II engines.

We also now have a Stirling engine in Army generators being fully tested at Fort Belvoir. We have another one going into an Air Force van and at the request of the Air Force. And I just came back from a week-long stint in Texas where the gas and oil industry and some of their investors are very interested in taking Stirling engines and applying them to the commercial-sized heat-pump situation.

So I believe that we have lived up to our promises to the subcommittee that we would get the private sector involved and that we would find market initiatives for these engines to start proving out their operation and warranty characteristics so that they could eventually be viable for the automotive marketplace.

That concludes my testimony. Thank you.

[The prepared statement of Dr. Lloyd Lawrence follows:]

Testimony

before the

Energy and Natural Resources Committee

Subcommittee on Research and Development

U.S. Senate

on the

DOE Conservation Budget

Mr. Chairman and Members of the Subcommittee. I am Dr. L. R. Lawrence, Jr., and I am Vice President for Technology Development with Mechanical Technology Incorporated (MTI). Our firm is a high-technology corporation dedicated to the development and application of high-efficiency energy conversion products and quality control equipment for manufacturing industry. MTI began in 1961 with 7 dedicated engineers, and through innovation, product development, and manufacturing, we have grown to a firm of 850 people and $60 million in annual sales. Slightly over one-half of our revenues come from the sale of products, and the rest is from engineering services and R&D.

I am here today to discuss the need for a strengthened DOE conservation technology budget, especially in the areas of Gas-Fired Heat Pumps, Industrial R&D, and Stirling Engines. These three areas are perfect examples of the types of programs recommended for funding by the President's Commission on Industrial Competitiveness. As many of you are aware, this Commission consisted of high-level people from American manufacturing industry, banking, universities, service entities, and the Administration. In their resulting report entitled "Global Competition, The New Reality," this Commission strongly supported the type of efforts that we are addressing in this hearing today. Quoting from pages 18-19 of this document:

> "Technology propels our economy forward. Without doubt, it has been our strongest competitive advantage. Innovation has created whole new industries and the renewal of existing ones. State-of-the-art products have commanded premium prices in world markets, and technological advances have spurred productivity gains. Thus, America owes much of its standard of living to U.S. preeminence in technology."

And continuing:

> "In order to make technology a continuing competitive advantage for the United States, we need to do three basic things: 1) create a solid foundation of science and technology that is relevant to commercial uses; 2) apply advances in knowledge to commercial products and processes; and 3) protect intellectual property by strengthening patent, copyright, trademark, and trade secret protections. Attaining these goals will require actions on the part of the Federal Government, industry, and our Nation's universities.

"There is not enough research and development with competitiveness as its goal. The United States currently spends more on research and development (R&D) than Japan, France, and Germany combined. As a percentage of gross national product, America spends slightly more on R&D than any of our competitors do. But these figures have led to a degree of comfort that is unwarranted.

"Roughly half of the total R&D done in the United States is funded by the Federal Government, which spends most of its money (about two-thirds) on defense and space programs. And in those two areas, any commercial spillover is not a prime objective. Thus, when we look at what the United States spends on civilian R&D, areas of innovation from which we can reap the greatest commercial reward, we find ourselves behind both Germany and Japan."

Mr. Chairman, the Nation this year is embarked on taking $60-80 billion out of the Federal Budget in response to the Gramm-Rudmann-Hollings Act. As we found in 1981-1983, when that amount of money is summarily removed from Government programs, it is removed from paychecks and plunges the country into a deep recession. The only way to avoid such a recession is to provide a mechanism for jobs; i.e., an increase in available dollars for paychecks from some other resource. We could find those dollars easily, if we could only correct our massive imbalance in trade. At this point, I must laud the efforts of Secretary Baker at the Treasury who is working tirelessly to bring the American currency more into line with foreign currencies, so that we may compete on a better financial basis. But that is not the entire answer. Price is only part of the competitive solution. It must be coupled with more attractive products. And as we have seen graphically in the past ten years, foreign government-industry teams, focusing on commercial items and their evolution, have consistently eroded our competitive position to the point where our balance of trade exceeded $143 billion in 1985. In total, our nation has lost $593.8 billion since 1975 through balance of trade deficits. Imagine the effect on our economy if those funds were still in this country under the control of American consumers. Instead, we have become an international debtor for the first time since 1917.

Our international indebtedness continues to grow, and some business experts predict that in the not-too-distant future, we may become the world's largest international debtor on a scale which will dwarf the indebtedness of such countries as Brazil and Mexico. According to a study by the Institute for International Economics, continuation of current trends could raise our international indebtedness to $1 trillion by the end of 1990. What do we do when we are overcome with such indebtedness and cannot pay back our loans? Threaten the world with dire consequences if they try to collect, using our massive military might which we, in peacetime, have recently assembled?

Mr. Chairman, a piece of military hardware creates jobs only when it is being built. There is no economic benefit associated with it when it is parked on a tarmac. In contrast, a commercial item requires financing, insurance, transportation, distribution, sales, and servicing, and continues in nearly constant use. It is a commercial item, then, which truly adds to our economic health.

With these thoughts in mind, Mr. Chairman, I would like to move on to a situation which has become critical, and which this Committee is in a unique position to do something about. The subject is the Gas-Fired Heat Pump.

GAS FIRED HEAT PUMPS

A gas-fired (or oil-fired) heat pump (the only difference being the burner design) is a device which uses the inherent energy in the atmosphere to provide highly efficient heating (or cooling) to a structure. By using the atmospheric energy properly, the heat that can be delivered to a house will contain more energy content than the amount of energy used to drive the device. In the heat pump itself, a fluid, such as Freon, is circulated in a refrigeration loop. Heat is added to the fluid where it is cold (i.e., outside, in the heating mode) and heat is removed from the fluid where heating is needed (i.e., inside the house). For the benefit of those who are new to this concept, I have included Figures 1 and 2 for clarification.

In the United States today, DOE estimates there are 50 million homes heated by gaseous fuel and another 15 million heated by oil or kerosene. These homes represent the candidate marketplace for gas- and oil-fired heat pumps. Most studies indicate that a well-performing gas- or oil-fired heat pump, with an installed cost of $4000 to $4500, will pay for itself in 3 to 5 years or less in much of the United States. This payback comes from a reduction in fuel use of 40-60% during the heating season. The same piece of equipment has the added advantage of being able to cool from the same fuel supply.

To examine the maximum possible market then (retrofit only), we can take the 50 million gas-fueled homes, add the 15 million oil-fueled homes, and arrive at 65 million homes to be multiplied by the installed cost of $4000. The result is then:

$$(50 + 15) \text{ million} \times \$4000 = \$260 \text{ billion}$$

I think you will agree, Mr. Chairman, that $260 billion is a large figure, even by Congressional standards. If we modify this figure a bit, for instance, reduce it by one-half to make it more realistic, the number is still $130 billion. If we now average this figure over 10 years (for a gross examination of the situation), we still come up with $13 billion per year, or an economic unit close to the size of United Technologies Corporation.

Why then, with such a large market potential, will not the American private sector "pick up the ball" and fund this technology themselves? The answer is complex, but can be basically broken up into the following parts:

a. The technology is perceived to be risky and will take at least three years to get to preproduction prototypes. Industry is looking for a payback in that time period, not just the start of a business.

b. The heating industry has been generally a low-technology, "metal bending" business and does not have a high technology base to draw on for the evolution of gas heat pump products.

WHAT'S A HEAT PUMP?

- Pumping Heat from a Cold Zone to a Warm Zone

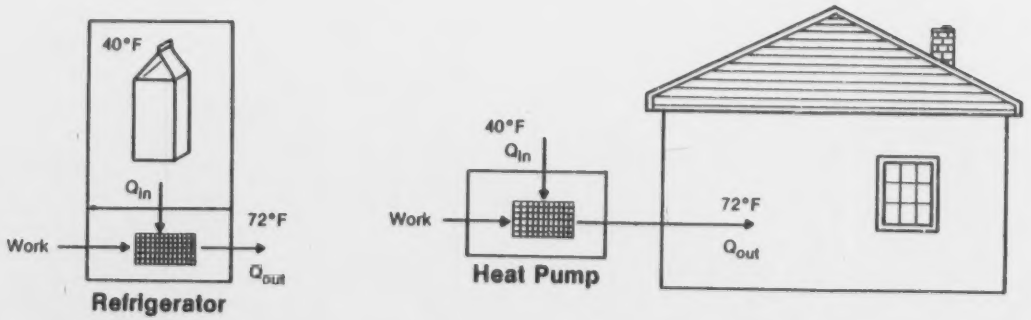

Figure 1

ENERGY RESOURCE USE IN HEAT PUMPS

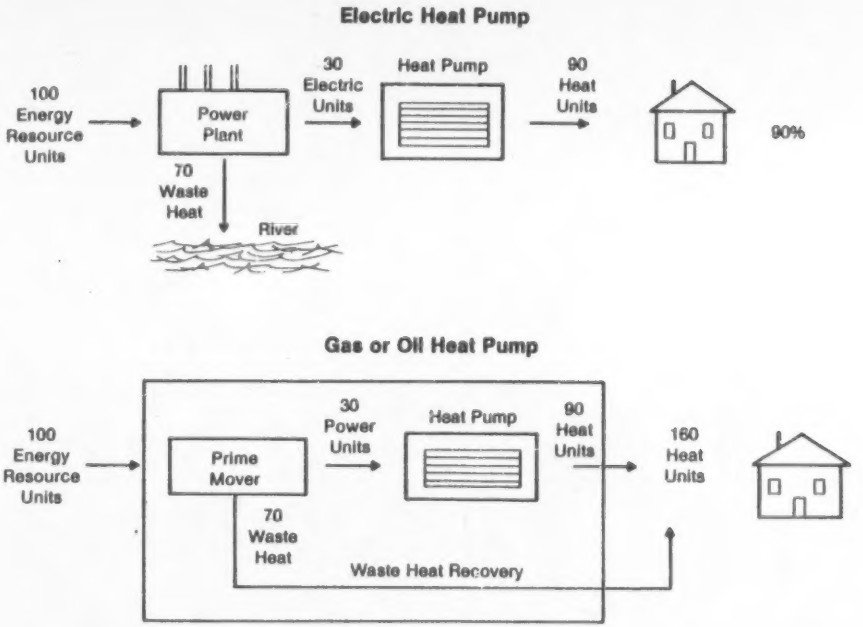

Figure 2

c. Private capital has too many other nearer-term opportunities in which to invest, which can return a profit sooner, such as buying an established business similar to its own. The risk involved with this route is very small.

In this environment, a number of United States contractors have been working on various gas heat pump concepts for more than ten years. These programs have been funded by a meager DOE program ($4 million per year) and a parallel effort by the Gas Research Institute. As a result of this effort, about four contractors have promising prototypes operating in laboratory test cells.

IN JANUARY OF THIS YEAR, THE JAPANESE DELIVERED TWELVE GAS HEAT PUMP UNITS TO THE UNITED STATES TO BEGIN FIELD AND MARKET TESTING.

Once again, the Japanese have found a massive market, focused their resources on it, and are attempting to take it over. The Department of Commerce states that over $49 million of Japanese government funds have been spent during the past few years on gas heat pump developments. This amount has been matched or exceeded by industrial contributions. The 650,000 jobs which are involved in an economic unit of $13 billion per year are of interest to the Japanese.

There is a bright spot in all this. In order to establish their marketing relationships, as well as service and distribution entities, the Japanese have taken the approach of introducing low-performing, high-maintenance gas heat pumps. The American prototypes operating in laboratories can beat the Japanese candidates, keeping the market and jobs for Americans, if only they are allowed to proceed to their full potential. Under the presently available funding, each American contractor has basically one prototype operating in a single test configuration. Spare parts are rare. In the case of our own company, we cannot pay our program manager on the contract, because it would take too much away from the research dollars.

What the program needs is $20 million per year for the next three years. This amount would allow four leading contractors enough money to operate and develop multiple prototypes, with appropriate spare parts. Under such a program, the contractors could have one prototype for each of the key areas of performance, durability, component development, and systems integration. With this type of effort, the units should be at the point, in three years, where the private sector would make the needed investment to take them to market.

The Government does not have to provide the entire $20 million per year. The Gas Research Institute has indicated it might cost share this effort, and some major portion of the $20 million per year may possibly come from them. I would encourage the Subcommittee to explore this with them.

Mr. Chairman, the gas heat pump situation is critical. The nation's future posture in this market and technology needs this Subcommittee's clear and undivided attention. Regardless of the present budget situation, I would hope that the Subcommittee would find this technology to be one of the highest national priority, and treat it accordingly.

INDUSTRIAL PROGRAMS

Mr. Chairman, over the last ten years, I have testified many times in support of DOE's Industrial Conservation programs. Although my corporation has only a very small vested interest in the Industrial programs, the nation has an enormous stake in their outcome.

I have been closely associated with Industrial Conservation programs since 1975, when, as one of the first executives at the Energy Research and Development Administration (ERDA), I watched the Industrial division formed with competent, dedicated people from industry who could readily understand and work with their industrial counterparts, while on the Government side of the equation.

At the inception, under a Republican administration, this division was chartered with the acceleration to market of promising technologies, of high perceived national benefit, which were 3-10 years from the market and had significant economic or technical barriers to overcome. This strategy was excellent in that it addressed the critical 3-10 year time period, which neither the private sector nor the Government normally addresses, and a payback from these efforts can now be measured. The work done in this Division falls exactly in line with the recommendations of the President's Commission on Industrial Competitiveness.

The Energetics Corporation has recently completed a study which examines the impact of the Industrial Conservation program since its inception. Paraphrasing this report, numerous technology improvements have been developed by this Division, jointly with private industry, and have been put into production and use. The technologies include:

Advanced Catalytic Reactors
Cogeneration - Coal-Fired Steam Turbines
Cogeneration - A Slow-Speed Diesel
Coil Coating
Computer-Controlled Ovens
Cupola Stack Air Injection
Dye Bath Reuse
Foam Finishing
Heat Exchange in Drying
High Efficiency Welding
Hyperfiltration - Textiles
Advanced Irrigation Systems
Nitrogen-Methanol Carburization
Organic Rankine Cycle Bottoming Units
Pipe-Cross Reactors
Plating Waste Concentrator
Recuperators
Slot Forge Furnaces

Numbers of units, based on these improved technologies, are now installed and operating across the United States, resulting in a substantial payback to the Government in terms of national benefits. Figure 3 shows that cumulative appropriations since 1975 of $311,145,000 have resulted in cumulative production cost savings to 1985 of $353,000,000. These benefits continue to

PROGRAM BENEFIT/COST ASPECTS

- Cumulative Appropriations Through Fiscal Year 1985 = $311,145,000
- Cumulative Production Cost Savings to 1985 (23 Successful Technologies) = $353,000,000
- Over 200 R&D Projects Supported to Date

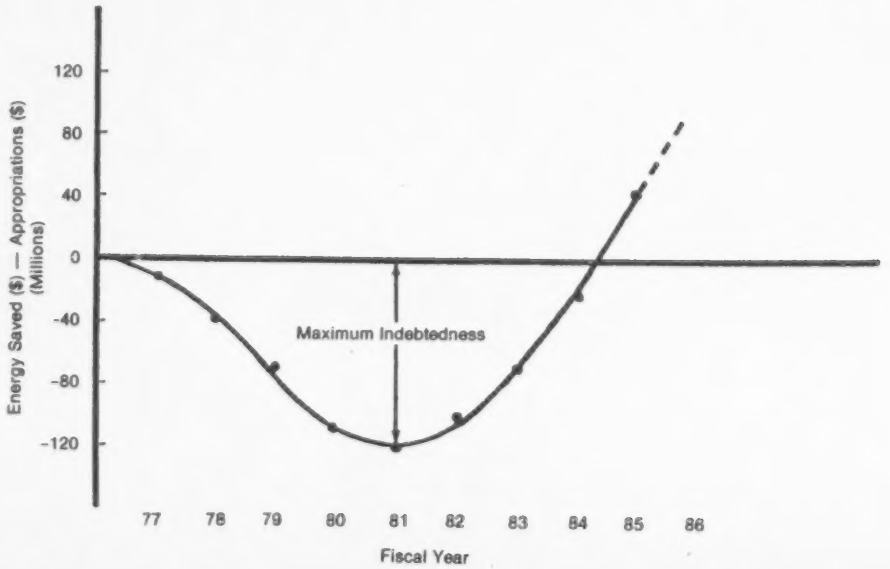

Figure 3

grow geometrically, as the technologies increase their penetration of the marketplace.

In the past few years, direction from administration policy makers has reduced the effectiveness of the R&D dollars spent in this division. Unfortunately, it has been moved away from that critical 3-10 year time frame and has been ordered into the framework of "long-term, high risk," wherein virtually no one can predict a national benefit with any assurance of its occurrence. With our national situation as it is, and the critical nature of our balance of trade, this division must be refocused at those things which it did an outstanding job of accomplishing, i.e., the acceleration and implementation of those higher risk, high potential benefit items which fall into the 3-10 year timeframe.

The recommendation then, Mr. Chairman, is that the Industrial Conservation programs be strongly preserved in the present budget process with strong language directing the Department to focus these programs on those technologies which are highly beneficial in nature, and which can be implemented in the 3-10 year timeframe.

STIRLING ENGINE PROGRAM

Finally, Mr. Chairman, it is my pleasure to present the successful status of the Automotive Stirling Engine program and to request $8 million for FY87 to complete the present contract. We are also supporting the broad-based Gas Heat Pump program. There is a desperate need for a stronger program to prevent major foreign incursions into this hundred billion dollar American market. In addition, we support the concept of a future multicontractor, broad-based Stirling technology effort in the nation, much as is found supporting both diesel and turbine concepts.

Mr. Chairman, in the Spring of 1981, this Committee had to make a difficult decision as to whether or not to let Stirling engine development continue in this country. We are thankful that you chose to support the Stirling effort, and we hope that you will see that we have, in fact, carried out the Congressional intent to evolve this technology into a variety of potential products with a great deal of promise of national benefit.

In 1978, when the contract first started, Stirling engines were little more than a laboratory curiosity. They were too heavy, unreliable, very expensive, contained rare metals, could not power a vehicle, and the technology base resided in Europe. Since that time, MTI has brought Stirling engines to the point where they are truly being considered as viable options for a whole series of applications - from vehicle propulsion to space power.

We are thankful, as well, to the NASA Lewis Research Center which has staunchly supported this program and has made a great many technical contributions leading to the greatly advanced status of the engines today.

The following chart provides a brief description of the present status of Stirling engines compared to their status in 1978:

	1978 Stirling P-40	1986 Stirling Mod II
Weight/Power (lb/hp)	14	5.5
Cost* ($)	5000+	1200
Acceleration** (0-60 mph) (sec)	36	12
Miles Per Gallon** (Combined City/Highway)	19	41
Rare Metals	Cobalt	None
Seal Life (hr)	100	2000+

*Based on 300,000 units per year
**3250-lb vehicle

Mr. Chairman, two and one-half years ago, MTI committed to the operational testing of a Mod II engine by January 31, 1986. In late January of this year, we followed through on our commitment by operating a Mod II for the first time in our laboratories. Although there is a substantial amount of testing and component improvement which must be accomplished before this engine will meet all the goals of the program, it is clear that the promise we projected in the past is, indeed, present in this design.

With an appropriation of $8 million for FY87, and with the private sector contributing the additional needed resources, we feel that the goals of this program will be met by the end of 1987, as we have projected for the last three years. This is, of course, predicated on the Congress rejecting the present recisions/deferrals. If these are not rejected, the resulting dramatic negative effects could cause the program to need as much as two additional years to reach the legislative goals.

To restate those goals briefly, the Mod II and derivative engines are expected to meet the original environmental standards for 1985 (NO_x < 0.4, HC < 0.41, CO < 3.4 gm/mi, and particulates < 0.2 gm/mi) and to show a 30% or greater improvement in gas mileage over comparable production engines, interchangeable operation on a variety of liquid fuels, reliability and life expectancy comparable to production engines, initial cost and life cycle cost comparable to production engines, acceleration suitable for safety and consumer considerations, and noise and safety characteristics meeting federal standards.

Perhaps the most important programmatic aspects of the past year are the increased industrial interest and the beginning of serious industrial participation in this program. Deere and Company is now actively involved with us in building the Mod II engines. They are cofunding this effort at a 25% level and have provided such items as a candidate Mod II engine block at their own cost. The Mod II parts being built by Deere are being produced using production-type tooling in engine production facilities. This is clearly the first step in the transitional process from government funding to private sector investment and commercialization, but it will be lost if FY87 funding is not forthcoming.

Two more promising events have been the Army's acceptance of a Stirling-driven generator set for testing at the Fort Belvoir R&D center and the Air Force's initiative to test a Mod I in a flight line van. The Army has severe problems in encampments and other field posts from the noise generated by current generator sets. The quietness of the Stirling, as well as its high efficiency, fuel flexibility, and paucity of needed spare parts are attractive to the military. Similarly, the Air Force has done a study (without our help) which leads to 23 specific reasons why Stirling engines (when fully developed) should be the propulsion units for Air Force ground vehicles. These reasons range all the way from high efficiency, low noise, and multifuel capability to low IR signature.

Other positive side effects from this program are the many other potential applications of Stirling technology which are now becoming evident. Product developments are now under way for heat pumps, cryogenic refigerators, space power generators, multifuel stationary engines, and high-efficiency oil-free pumps.

In addition, the program has produced a wealth of scientific and technical information which is publicly available and applies to a broad cross section of technological applications. As part of this program, major advances have been made in materials, controls, combustion, heat transfer, regenerators, ceramics, seals, casting, and computer analysis. This technology base is available to researchers nationwide for applications to numerous fields of endeavor.

The appropriation of $8 million, then, and the rejection of the deferrals/recisions will lead to the successful conclusion of the Stirling Engine development contract during FY87.

We would also advocate a continuing program in Stirling engine technology, involving a number of contracters, to ensure that the United States maintains its leading position in this technology. This would be consistent with the fact that the United States has basic research and development efforts ongoing in many government agencies in both diesel and turbine technology. Now that the Stirling potential has been established, it too should be addressed with continuing technology base programs for the same reasons that we fund both diesel and turbine efforts. For example, the external burning feature of a Stirling makes it the most attractive engine option for the direct use of coal. It would be in the national interest to pursue this application. Our recommendation, then, is that in FY87 a technology base program should be established in the $4 million range. This would be sufficient to attract other contractors and would begin to broaden the Stirling capability base. These funds would be over and above the $8 million needed to complete the Automotive Stirling Engine Development contract.

It should be mentioned that the promise and success of Stirling development efforts have not been overlooked by the Japanese. During the past year, we have been given information on a number of ongoing efforts within that country aimed at evolving a variety of Stirling-based products. It is our understanding that two major Japanese automotive companies have ongoing efforts to evolve automotive Stirling engines, with plans for commercialization within five years or so. In this environment, the Japanese have admitted that the

United States still has the lead in this technology. However, we are now clearly in a difficult race with a considerable amount at stake.

In closing, Mr. Chairman, I would like to quote from an editorial by Morton Zuckerman, Chairman and Editor-in-Chief of U.S. News and World Report. The editorial was published on December 23, 1985. Zuckerman stated:

> "The high technological edge enjoyed by Americans in the 1950s and 1960s has disappeared. Whereas America once had effortless economic superiority, it is now faced with world class competitors who have matched its technological and economic achievements and may well be in the process of moving ahead of it. If trends continue, America's standard of living will fall relative to those of the world's new industrial leaders, such as Japan and Korea - and protectionism guarantees things will get worse because it removes the spur of competition."

And continuing:

> "Any political leader or party wishing to lead America will have to make politically feasible what is economically necessary. We have a positive policy to save our lives. We urgently need one to save our livelihoods."

Mr. Chairman, I thank you for the opportunity to present these thoughts to you and your Subcommittee.

Senator EVANS. Thank you.

Dr. Ridgway is next.

Dr. LLOYD LAWRENCE. Mr. Chairman, may I ask you a brief question? Unfortunately, the situation is that a 4:10 airplane is going to make my family very, very happy. Could I possibly have questions submitted for the record and I will be happy to answer them.

Senator EVANS. Surely. Or let me ask a couple of questions right now and we will let you on your way. I think I appreciate the opportunity to get back to a family on rare occasions more than you can possibly know. So I sympathize with you.

Dr. LLOYD LAWRENCE. Thank you.

Senator EVANS. It seems to me, and I'm a little quizzical about your statement on heat pumps. If, indeed, it is something, as you say maybe conservatively, a $15 billion-a-year industry and you are talking about only a 3-year program which presumably would get us to the point where we begin to tap into that kind of a commercial venture, and if the total cost is $20 million a year for 3 years, I cannot understand why industry is not thirsting to chase each other out to grab that market.

I bet I could come up with a whole lot of other examples where single companies or a combination of companies, through an industry association, have put up a lot more money than that to come up with a commercial technology in the market that is a lot less than $13 billion a year. Why is that not happening here?

Dr. LLOYD LAWRENCE. I think that is happening here. I would like to say, Mr. Chairman, that if you have personal knowledge of folks that might be helpful here, we would be more than happy to work with them. We have tried very hard to work with the private sector at this point, and the problem is we are at least 3 years away in our own case—there are like several other contractors like us in similar situations—we are 3 years away from what we would call a preproduction prototype.

At that point you are not really even in the business. At that point you are making a tooling-up decision, which means more expenditure and you are really only in the business about 2 years after that in terms of selling anything and getting your return. In fact, it was the first week in March I had a big meeting at our plant where we worked very hard. We had a couple of bank presidents and we had some manufacturing and industry people right at the top of manufacturing industry, and a couple of people who tend to invest in the $5 to $10 million block category that we invited to our place. In fact, we had a total of 14 of them there.

I went through this precise program on our prototype talking about the fact that it was 3 years to preproduction and we spent a whole day with these people on this. And when we got to the point where we told them exactly the timeframe and the dollars, we had people reaching for airplane tickets and people asking what the travel arrangements were, and irate people asking me why I had brought them all this way for something that was 3 years out of preproduction prototype.

So it has been a little bit of a frustrating experience in attempting to lure these fellows. I think it is, unfortunately, a situation where there are a lot less riskier things to do with money that have a lot shorter time return, like, buy a company; that is the di-

rection the country is going right now. It's just not headed toward these riskier things, regardless of the amount of payoff at the end.

Senator EVANS. Maybe we ought to send some of our people to different MBA schools than Harvard and Stanford that are turning out that kind of management.

On the Stirling engine, this is, I know, at least the third report I've sat in on where you have testified on the progress which, in each case, appears to be quite substantial. But what is your outlook again on this one? How far are we away?

You say the progress has been very substantial. You are getting the transitional process from Government funding to private sector investment in commercialization. But it will all be lost if fiscal 1987 funding is not forthcoming. How much funding would be required for a continuation from Government in your company for this particular product?

Dr. LLOYD LAWRENCE. We have been consistent for the last 2 years in that, I believe, Mr. Chairman. We are consistent one more time. Fiscal 1987 would be the last year for the main program. We are asking for $8 million for fiscal year 1987. I might point out that we expect the private sector to pick up the additional $4 million that would be needed to complete the program in fiscal year 1987 through a variety of sources.

Senator EVANS. To finish the program?

Dr. LLOYD LAWRENCE. Yes. We have been consistent in that in the last 2 years and we are consistent again. Fiscal 1987 will be the last year of the automobile Stirling engine program. I might point out that——

Senator EVANS. What do you have in hand for fiscal year 1987?

Dr. LLOYD LAWRENCE. At the end of fiscal year 1987 we will have the MOD II pretty well developed. It should be to the point where it would be attractive enough to the private sector that we can move on with that. We feel it truly will be.

I have a chart on page 10 of the testimony basically showing the kinds of progress we have made in the 8 years of the program, reducing things like the weight power from 14 pounds of horsepower down to 5.5, reducing the costs way down and taking a lot of the unreliable aspects of the engine into making them reliable.

So we truly feel that we will be there. It will be time for the private sector to pick it up in fiscal 1988. I might point out at this time, Mr. Chairman, we are under the deferral thing, and we have in fact gone through a layoff last week. So we had laid off some of the folks that represent the world's leading group in this technology. If the deferral is not reversed, then I don't think any of this makes too much sense because we will simply have to eliminate what the country presently has in this capability.

Senator EVANS Do you have an interest at this point an interest to the degree of providing any resources for continued advancement from any of the three major automobile companies in the country?

Dr. LLOYD LAWRENCE. The General Motors Corp. tends to kind of reflect who you ask there. We have had exactly the kind of support we would hope for from them to date. They have taken one of our automobiles with an engine in it and fully tested it 1½ years ago and have indicated they would do the same with the MOD II. I

think they have a very large corporation and a tremendous amount of product at stake and for them to do much more than that at this point in time would be unrealistic, I think.

The other two, both Chrysler and Ford have been watching and have been participating with us occasionally and have been sitting and waiting to see whether we could do what we claim we can with the Mod II.

Senator EVANS. Apparently, that same attitude does not prevail in Japan, where you say in your testimony that two major Japanese automobile companies, which presumably have just as much at stake in current technology and production, are moving quite rapidly. Is that accurate?

Dr. LLOYD LAWRENCE. I think it's even worse than that, Mr. Chairman. We personally right now find ourselves under a great deal of pressure from a couple of large Japanese companies who have approached us and have offered us a great deal of money to transfer this technology to Japan.

We have taken the position that this country has paid for the technology; people like yourself have supported us for a number of years, and we think this should be something to help our competitiveness and not hurt it. As long as that is possible, that is the way we are going to go with this.

Senator EVANS. So, as I understand it, two comparable automobile companies, national overall leaders—I don't know which Japanese companies they are, but I would guess they are probably some of the big ones.

Dr. LLOYD LAWRENCE. There are two major Japanese industrial firms. Neither is an automotive company. They both have manufacturing capabilities for engines.

Senator EVANS. Well, whether you put it alongside the American engine company, automobile company, or whatever, it seems to me that there are parallels in both the heat pump as you mentioned and now in this engine, that the attitude of the American company is wait and see until it's proven so there is no risk to us. And then we might be interested in doing something.

Whereas, the Japanese are saying, this is a new idea; we are trying to do something better to keep a technological edge. So we are willing to put an investment, even if there is risk. Is that a pretty fair estimate of the attitude?

Dr. LLOYD LAWRENCE. I think it really is, Mr. Chairman. Unfortunately, I do not know of a corporate entity in the United States that has national benefit as an investment criteria. In Japan it is different.

Senator EVANS. But in this case, whether the national benefit flows out of that. But it is also, I guess, they are looking at least primarily to some commercial benefit, potential commercial benefit. They just have a longer time on it, in terms of their attitudes.

Dr. LLOYD LAWRENCE. I think that is certainly true.

Senator EVANS. That is a sad commentary on our own industrial leadership, it seems to me.

Thank you very much for coming. It is interesting each year. I hope one of these years you will drive one of your cars up to the door and thumb your nose at General Motors on the way.

Dr. LLOYD LAWRENCE. It will happen.

Thank you very much, Mr. Chairman.
Senator EVANS. Dr. Ridgeway?

STATEMENT OF DR. STUART L. RIDGEWAY, PROGRAM MANAGER, R&D AND ASSOCIATES

Dr. RIDGEWAY. Mr. Chairman, I thank you for this opportunity to present this testimony to the subcommittee. I am Dr. Stuart Ridgeway, program manager at R&D and Associates and I will talk about this engine and its experiences in DOE.

The purpose of the Ocean Thermal Energy Program in the U.S. Government is to develop the technology to exploit enormous energy resource in tropical oceans. The temperature difference between the surface and the depths of these oceans can be used to power a heat engine to make electricity. So far the engines that use conventional technology have been far too expensive.

In 1977 the mist lift process, a new inexpensive heat engine concept to harness the OTEC resource, was introduced to the OTEC community. DOE research support of about $600,000 bore fruit in 1980–81 and the technical feasibility was demonstrated in laboratory scale experiments. Operation on the ocean resource was accomplished in a Solar Institute Research Institute supported experiment in 1983 at Ke-ahle Point, HI. However further development has ceased due to budgetary constraints.

A recent cost study shows that the mist lift powerplant will cost about $1,500 per kilowatt. This cost is competitive with the cost of a coal-fired plant with scrubbers, considerably less than that of a nuclear plant, and less than half of the costs anticipated for other OTEC schemes. Therefore, simple economics dictate that the develop should resume.

At present, DOE funds for OTEC are inadequate, particularly when the appropriated money is not spent. The development of an advanced OTEC technology is an appropriate area for Government research and development. The largest rewards of the successful development and commercialization of OTEC will fall mostly to the consumers of electricity or energy-intensive products, so it is right and reasonable that they take on the development risks.

Utilities would have little or not payoff since their regulatory commissions will only reduce their rates if such a development succeeds and may not even allow the sunk R&D costs into the rate base if it fails.

The equipment manufacturer has slightly more incentive since he will profit by selling the new equipment. However, he is already profiting by selling oil, coal, or nuclear power generator technology and he will lose some business as he gains some. He is reluctant to take the risk—his potential payoff is small and could even be negative.

The benefits of a successful OTEC development will be reaped by all of us, so we, the consumers, should take the risks.

The blanket cuts in DOE programs under Gramm-Rudman have the effect or restricting the accomplishment of the established programs, and preventing support of significant new innovative developments. We will fall behind in what we are best at, the innovation

of new technology, if the present policies in the support of research are allowed to continue.

We increase tomorrow's deficit in the attempt to reduce today's deficit. I urge the Congress to support OTEC research and to encourage DOE to adequately support innovative breakthrough OTEC technology that can have a high economic return.

Thank you.

Senator EVANS. Thank you, Dr. Ridgeway.

[The prepared statement of Dr. Ridgeway follows:]

TESTIMONY OF DR. STUART L. RIDGWAY
TO BE DELIVERED BEFORE THE
SENATE SUBCOMMITTEE ON ENERGY RESEARCH & DEVELOPMENT

The Ocean Thermal Energy (OTEC) program of the United States Government hopes to develop the technology to exploit the enormous energy resource of the tropical oceans. There is a temperature difference between the surface and the depths of these oceans that can be used to power a heat engine to make electricity. So far the engines that use conventional technology have been far too expensive.

In 1977 the Mist Lift process, a new inexpensive heat engine concept to harness the OTEC resource, was introduced to the OTEC community. Department of Energy (DoE) research support of about $600,000 bore fruit in 1980-81 and the technical feasibility was demonstrated in laboratory scale experiments. Operation on the ocean resource was accomplished in a Solar Institute Research Institute (SERI) supported experiment in 1983 at Ke-ahole Point, Hawaii. Further development has ceased due to budgetary constraints.

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The benefits of a successful OTEC development will be reaped by all of us, so we the consumers should take the risks.

The blanket cuts in DoE programs under Gramm-Rudman have the effect of restricting the accomplishment of the established programs, and preventing support of significant new innovative developments. We will fall behind in what we are best at, the innovation of new technology, if the present policies in the support of research are allowed to continue.

Senator EVANS. Mr. Bazjanac.

STATEMENT OF VLADIMIR BAZJANAC, ENERGY CONSULTANT

Mr. BAZJANAC. Thank you for the opportunity to appear before you today. My name is Vladimir Bazjanac, and I am an energy consultant. As a building energy consultant, I work closely with architectural and engineering teams which are commissioned to design some of the largest and most complex buildings in the United States.

Over the last 9 years, I have been involved with projects totaling almost two thirds of a billion dollars worth of new construction. In my role as an energy consultant, I am called upon to help develop solutions that will meet the client's energy and cost criteria or to advise the design team on ways to improve the energy efficiency of their proposed design solutions.

Windows are a major reason for energy use in buildings; they now account for about 5 percent of total U.S. energy consumption or an amount equivalent to the output of the Alaskan oil pipeline. Although people have always desired windows in buildings, the mistaken assumption that windows only increase energy costs led in the past to poorly formulated building codes which limited allowable window area.

Research supported by the Department of Energy at Lawrence Berkeley Laboratory has helped to prove that if the benefits of windows are properly accounted for, windows can perform better than the best insulated wall or roof. This has resulted in the modification of many codes which now permit more liberal and more energy efficient use of windows.

In my experience on specific building projects, it is now usually possible to meet or exceed the most stringent code requirements. In some cases we have reduced energy consumption 20 to 50 percent below current requirements and as much as 80 percent below typical practice in 1975.

If widely implemented, these savings will substantially reduce fuel and electricity requirements and the need to invest in major new energy generation facilities.

Our new understanding of how buildings and their occupants benefit from windows has spurred the development of new glazings, new window systems, new lighting controls and new lighting systems. This, in turn, has created new companies and new jobs in the building industry.

The understanding of how new technologies work has allowed consultants like myself to help create better building design solutions previously not considered, and to achieve performance previously deemed impossible. It is vitally important to the design community, and to the building industry, in general, that this development of knowledge continues.

Let me give you specific examples of how federally supported building energy research has provided essential new tools and information to the building design community and how it has helped accelerate the development of new building products.

One of my recent consulting projects involved the design of the Pacific Museum of Flight in Seattle, WA. The design for the build-

ing calls for a very large glass structure which would not have been acceptable if it used conventional glazings; it requires special glass which allows the transmission of daylight while it blocks most heat and ultraviolet rays.

Such special glazings were made possible by DOE's early support of new coating technology development at Southwall Corp. The success of this research stimulated private sector investment in Southwall and led to the development of a new manufacturing facility to produce heat mirror.

Other manufacturers, including most of the largest glass and window firms, have entered the market since. Research on the performance of these glazings by the Windows and Daylighting Research Group at Lawrence Berkeley Laboratory has made it possible to undewrstand how the coatings affect the building performance, which in turn, helps to justify their use in buildings like the Pacific Museum of Flight.

An aircraft designer would not dream of designing or testing a modern airplane without first test flying. Similarly, a complete understanding of the energy performance of a building design can be achieved only through simulation with computer-based models which take into account all known aspects of performance.

Simulation models which offer such capability are very complex. While a number of such models are available, I found in my work that only one is versatile enough to simulate the energy performance of virtually any building—that is, DOE-2.

This model was developed with DOE support by the Building Simulation Group at Lawrence Berkeley Laboratory and the group is continuously upgrading the program with new features. The energy performance of the Pacific Museum of Flight could not have been demonstrated without the use of this model and the building would have required exemption from building codes.

The use of daylight to reduce lighting energy requirements is one of the most important strategies I am asked to evaluate. Daylighting always affects thermal performance. The simulation of this effect in real lift projects and buildings was previously not possible and had to be guessed or approximated.

The windows and Daylighting Group and the Building Simulation Group were instrumental in providing one of the most important breakthroughs in the analysis of the energy performance of buildings: the linking of thermal and daylighting performance in the DOE-2.1B simulation model. This new tool of analysis permits much better, earlier and more accurate understanding of the energy performance of individual buildings and design solutions.

Everybody benefits from this development. The productivity of professionals like myself has increased dramatically. Architects can justify solutions employing more expensive and complex fenestration systems. Value engineering and life cycle costing can be more accurate.

Owners can make more informed decisions on construction and operating costs. Utilities can achieve some of their goals of shifting portions of demand from peak to offpeak hours. The building industry can better justify investments to develop new products: glazings, lighting systems and controls. The general public can enjoy

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better indoor working environments. Society conserves energy and reduces pressure on supplies of nonrenewable resources.

The Windows and Daylighting Group has also created and operates the only scientific daylighting test facility in the United States available to test proposed building designs: a sky simulator.

The designs of several large commercial buildings I have been involved with were justified and accepted only after tests in the sky simulator.

Both of the research groups at LB–L I have mentioned are doing work that even the largest firms in the country cannot undertake by themselves, because of the complexity of the tasks and the cost involved. For example, no design firm in the country, not even firms with the largest volume of work, can afford to develop and operate its own sky simulator.

The results of the groups' work are available to everybody; big and small firms benefit alike. The groups 'researchers continuously contribute the technical information; for example, the Windows and Daylighting Group has released only 100 publications just on fenestration performance.

Finally, I want to emphasize that those of us who extensively use computer-based models in our consulting work must have confidence that our simulations are reliable representations of performance after a building is built and occupied. It is particularly important that our performance studies be done by a technically competent but disinterested, objective party.

Thus, we must rely on results of DOE-supported research for field measurements and validation.

I understand that much of the work supported by the Department of Energy may be phased out because of the proposed reductions to the Federal budget for Energy Conservation Research and Development. I am deeply concerned about the future of the work done by the Windows and Daylighting Group and the Building Simulation Group.

The private sector needs the results of this work. Yet, it does not have the concentration of skills and facilities, nor the individual or collective resources necessary to do the work itself. Who else is going to do this work if support for this research is eliminated?

I share the administration's concern for reducing Federal Deficit, but I think it is a false economy to slash support for a unique and very productive research program which provides vital and otherwise unobtainable information that is essential for the economic health of the building sector.

Abandoning support for programs as effective as these is counterproductive and clearly not in the best national interest.

I thank you for the opportunity to speak before you today, and I would be pleased to answer any questions you may have.

[The prepared statement of Mr. Bazjanac follows:]

Testimony of Vladimir Bazjanac
to the
Senate Subcommittee on Energy Research and Development
March 17, 1986

Thank you for the opportunity to appear before you today. My name is Vladimir Bazjanac and I am an energy consultant. As a building energy consultant I work closely with architectural and engineering teams which are commissioned to design some of the largest and most complex building projects in the United States. Over the last nine years I have been involved with projects totalling almost two thirds of a billion dollars worth of new construction. In my role as an energy consultant I am called upon to help develop solutions that will meet the client's energy and cost criteria or to advise the design team on ways to improve the energy efficiency of their proposed design solutions.

A building's energy performance is determined by many factors. One of the most significant is a building's interaction with its surrounding environment. This is also the factor most explicitly controlled by architects. The positive aspects of the interaction take place almost entirely through openings in the building envelope: windows and skylights. The balance between gains and losses through glazing is one of the critical factors which determine the performance of a building.

The design of fenestration often affects the architectural appearance of a building more than any other single feature, and as such is considered very carefully by architects. It is also very important to the owner and to the occupants whose environment inside the building is often enhanced by contact with the outside.

Windows are a major reason for energy use in most buildings; they now account for about 5% of total U.S. energy consumption, or an amount equivalent to the output of the Alaskan oil pipeline. Although people have always desired windows in buildings, the mistaken assumption that windows only increase energy costs led in the past to poorly formulated building codes which limited allowable window area. Research supported by the Department of Energy at Lawrence Berkeley Laboratory (LBL) has helped to prove that if the benefits of windows are properly accounted for (use of solar gain in winter, use of daylight to reduce electric lighting

year round) windows can perform better than the best insulated wall or roof. This has resulted in the modification of many codes which now permit more liberal, and more energy efficient, use of windows.

In my experience on specific building projects, it is now usually possible to meet or exceed the most stringent code requirements. In some cases, like in the State Office Buildings designed and built in California after 1979, in the Hawaii Medical Services Association headquarters in Honolulu, in the Farm Credit Banks building in Spokane, WA., in the Nevada National Bank building in Reno, in Ohio's Stouffer Corporation's newest hotel in Palm Springs, and in many other buildings, we have reduced energy consumption 20-50% below current requirements and as much as 80% below typical practice in 1975. If widely implemented, these savings will substantially reduce fuel and electricity requirements and the need to invest in major new energy generation facilities.

Our new understanding of how buildings and their occupants benefit from windows has spurred the development of new glazings, new window systems, new lighting controls and new lighting systems. This in turn has created new companies and new jobs in the building industry. The understanding of how new technologies work has allowed consultants like myself to help create better building design solutions previously not considered, and to achieve performance previously deemed impossible. It is vitally important to the design community, and to the building industry in general, that this development of knowledge continues.

Let me give you specific examples of how federally supported building energy research has provided essential new tools and information to the building design community and how it has helped accelerate the development of new building products.

One of my recent consulting projects involved the design of the Pacific Museum of Flight in Seattle, WA. The design for the building calls for a very large glass structure which will house the collection of historic aircraft. This design would not have been acceptable if it used conventional glazings; it requires special glass which allows the transmission of daylight while it blocks most heat and ultra-violet rays. Such special glazings were made possible by DOE's early support of new coating technology development at Southwall Corporation. The success of this research stimulated private sector investment in Southwall and led to the development of a new manufacturing facility to produce Heat Mirror,

the first of the new "low-E" coatings. Other manufacturers, including most of the largest glass and window firms, have entered the market since. Research on the performance of these glazings by the Windows and Daylighting Research Group at Lawrence Berkeley Laboratory has made it possible to understand how the coatings affect the building performance, which in turn, helps to justify their use in buildings like the Pacific Museum of Flight.

An aircraft designer would not dream of designing or testing a modern airplane without first "test flying" it thousands of times in a computer. Similarly, a complete understanding of the energy performance of a building design can be achieved only through simulation with computer-based models which take into account all known aspects of performance. Simulation models which offer such capability are very complex. While a number of such models are available, I found in my work that only one is versatile enough to simulate the energy performance of virtually any building: DOE-2. This model was developed with DOE support by the Building Simulation Group at Lawrence Berkeley Laboratory and the group is continuously upgrading the program with new features. The energy performance of the Pacific Museum of Flight could not have been demonstrated without the use of this model and the building would have required exemption from building codes.

The use of daylight to reduce lighting energy requirements is one of the most important strategies I am asked to evaluate. Daylighting always affects thermal performance. The simulation of this effect in real life projects and buildings was previously not possible and had to be guessed or approximated. The Windows and Daylighting Group and the Building Simulation Group were instrumental in providing one of the most important breakthroughs in the analysis of the energy performance of buildings: the linking of thermal and daylighting performance in the DOE-2.1B simulation model. This new tool of analysis permits much better, earlier and more accurate understanding of the energy performance of individual buildings and design solutions.

Everybody benefits from this development. The productivity of professionals like myself has increased dramatically. Architects can justify solutions employing more extensive and complex fenestration systems. Value engineering and life cycle costing can be more accurate. Owners can make more informed decisions on construction and operating costs. Utilities can achieve some of their goals of shifting portions of

demand from peak to off-peak hours. The building industry can better justify investments to develop new products: glazings, lighting systems and controls. The general public can enjoy better indoor working environments. Society conserves energy and reduces pressure on supplies of non-renewable resources.

The Windows and Daylighting Group has also created and operates the only scientific daylighting test facility in the U.S. available to test proposed building designs: a large 24-foot-diameter Sky Simulator. The complexity of daylit environments and the limited available analytical understanding of how to model such environments has made the simulation of daylighting performance with mathematical models satisfactory only in simple situations. For complex building designs, daylighting performance can be reliably predicted only through photometric measurements in scale models of buildings. Such studies require the controlled simulation of the changing illuminance of the sky, which can only be achieved in a sky simulator. In my experience, many energy saving designs, featuring innovative use of glazing, cannot be justified without such photometric studies.

The LBL Sky Simulator has made such studies possible. The facility is used by LBL staff in research studies but it is also available to practitioners such as myself. The designs of several large commercial buildings I have been involved with were justified and accepted only after tests in the Sky Simulator. It is the only facility in the United States which has the ability to simulate the full range of sky conditions, has the instrumentation to take the necessary detailed measurements and the trained staff to help interpret test results. The architectural profession has recognized the value and importance of this unique facility, developed as part of the LBL/DOE building research program, with a Research Citation in the Progressive Architecture Annual Awards program in 1985.

Both of the research groups at LBL I have mentioned are doing work that even the largest firms in the country cannot undertake by themselves, because of the complexity of the tasks and the cost involved. For example, no design firm in the country, not even firms with the largest volume of work, can afford to develop and operate its own sky simulator. The results of the Groups' work are available to everybody; big and small firms benefit alike. The Groups' researchers actively participate in the activities of all major professional societies that influence the design community: ASHRAE, AIA, IES, and others. They continuously contribute basic

technical information; for example, the Windows and Daylighting Group alone has released over 100 publications just on fenestration performance.

Finally, I want to emphasize that those of us who extensively use computer-based models in our consulting work must have confidence that our simulations are reliable representations of performance after a building is built and occupied. We often have to discount information on product performance published by industry groups that stand to benefit from it. It is particularly important that performance studies be done by a technically competent but "disinterested", objective party. Thus we must rely on results of DOE-supported research for field measurements and validation. DOE has supported the development of a unique field test facility, the **Mo**bile **Wi**ndow **T**hermal **T**est Facility (MoWiTT), to measure the performance of windows under actual operating conditions in the field. The glass and window industry serve in an advisory role to the LBL team conducting the research. This coordinated DOE/industry effort assures me that the results will be useful, relevant and objective. This helps build my confidence in the use of new glazing technology and in the validity of the simulations I use in my consulting work.

I understand that much of the work supported by the Department of Energy may be phased out because of the proposed reductions to the federal budget for Energy Conservation R&D. I am deeply concerned about the future of the work done by the Windows and Daylighting Group and the Building Simulation Group. The private sector (architectural and engineering firms and the building industry) needs the results of this work. Yet, it does not have the concentration of skills and facilities, nor the individual or collective resources necessary to do the work itself. Who else is going to do this work if support for this research is eliminated?

I share the Administration's concern for reducing the federal deficit, but I think it is a false economy to slash support for a unique and very productive research program which provides vital and otherwise unobtainable information that is essential for the economic health of the building sector. Abandoning support for programs as effective as these is counter-productive and clearly <u>not</u> in the best national interest.

I appreciate the opportunity to speak before you today and I would be pleased to answer any questions you might have.

Senator EVANS. Thank you very much.

First, Mr. Ridgeway, you mentioned that Mist Lift powerplants will cost about $1,500 per kilowatt. What is that based on and what does that relate to? Is that construction cost, life cycle cost? Is it in some years standard dollars? Can you tell me?

Dr. RIDGEWAY. The cost was constructed out of a design based on a modest extrapolation of the data we had gotten in the laboratory scale experiments. We assumed that it would work in the large scale that we did in the small scale.

And in particular we put the components in, we added them up, we got bids on some of the components, and then added about 20 or 30 percent for contingencies. In particular it was based on mining the flasks in which the lift takes place out of the face frock of the island on which it would be prepared and the size of the powerplant was 40 megawatts.

Senator EVANS. That is not really life cycle cost; that's initial construction?

Dr. RIDGEWAY. That's what it would cost you to buy the plant. That is when they quote other powerplants, again; when they quote a nuclear plant, that is what it costs to buy it.

Senator EVANS. But it is a considerably different life cycle cost; you do not have an estimate of your life cycle cost in kilowat hour?

Dr. RIDGEWAY. I suspect it is not going to wear out any faster than any other conventional piece of large-scale equipment, and probably it will wear out slower because it uses materials and concepts derived from the hydroelectric power industry and hydroelectric turbines and flow passages and channels are of great durability.

Senator EVANS. As far as I understand it, you have concluded that essentially laboratory scale model and funding has been cut off at that point?

Dr. RIDGEWAY. Yes.

Senator EVANS. Is there any interest in any other resource to continue that beyond the laboratory experiment into what I expect next would be somewhere between that and a prototype full scale.

Dr. RIDGEWAY. We have been under sort of continuous discussions with Solar Energy Institute to pick up and go forward with it. The apparatus is now sitting over there on the beach in Hawaii waiting for money to go forward and expand the data base and prepare the design of a larger system.

But it competes with your other requirements for carrying their ongoing program, which got started long ago and when you are reducing the budget, you can scarcely keep your own organization going, let alone spend a little money on a new idea.

So they want to do it, but they cannot do it.

Senator EVANS. How was SERI funded?

Dr. RIDGEWAY. Pardon?

Senator EVANS. How were they funded?

Dr. RIDGEWAY. They were funded in this area from conservation renewable energy. It is an item in there in the budget that Donna Fitzpatrick——

Senator EVANS. They are funded by the Federal Government?

Dr. RIDGEWAY. Yes.

Senator EVANS. Mr. Bazjanac, the window systems you mentioned—I came to this job from many, many years ago as a structural engineer, so I have some idea of what you are talking about, and then serving on the Pacific Northwest Regional Power Council, I found the opportunities for conservation and better efficiency were astronomical with a lot of them in the commercial side of things.

To what degree have the activities that you have been talking about here and the really striking energy consumption requirements on new buildings, how much of that in your view could be translated to existing or retrofitted commercial buildings?

Mr. BAZJANAC. Retrofitting is a difficult proposition because it requires first cost and expenditure right away, and unless there is a lot of money available for the particular building, it is a little difficult to convince the owner; it is typically simpler to reuse the building in a different way, sell it something like that.

Unfortunately, we are still stuck with a large percentage of old building stock; but we are basically changing our building stock to newer buildings and there is no reason why our future buildings should not be even much more energy efficient than they are now.

Congresswoman Schneider mentioned 150 billion dollars' worth of savings from conservation. Whatever proportion, I understand that the building sector itself accounts for about 40 percent of the national energy consumption. I would think that the energy consumption of buildings that has now been saved from the effect, whatever it is, proportion of the $150 billion could be twice as much.

I really do not see any reason why we could not conserve twice as much money than we are doing now. We are still wasting an awful lot. That is the tip of the iceberg.

Senator EVANS. I would guess that interest in retrofit would rise substantially if energy costs rose.

Mr. BAZJANAC. We are in a situation now where everybody says, "Oh, let us not worry about energy anymore because it is cheap once again." I really question the wisdom of the reasoning like that. It seems to me that no matter how long we can stretch this low cost of energy of today, eventually it will catch up with us, whether it be 2 years, 20, or 200 years, we are going to run out of renewable resources.

So it is just—really, it is——

Senator EVANS. Well, that is right. I had a personal experience coming from the Pacific Northwest back to our home in Washington, DC. That was an OPEC shock and a half to find out what the electric rates were here compared to there; I got considerably more interested in retrofit.

You mentioned the sky simulator. I would guess that that is really typical in a lot of professions. Now the development of large and maybe quite expensive, but nonetheless exceptionally useful simulators of one kind or another to aid in the design or carrying forward of the profession.

In this case I know it happens in the medical profession and certainly in the architectural and engineering profession. Is it not feasible that something like a sky simulator could be run by an inde-

pendent for-profit group who sold services to various architectural and engineering firms?

Mr. BAZJANAC. I think that would be really difficult. Let me explain why I think so.

The sky simulator does not really cost that much to build but it requires very high skill and it requires skill to operate and that skill exists at LBR right now. There are several sort of small scale sky simulators or partial sky simulators, if you want to, in the country now.

But the one at Berkeley is the only one which offers you the opportunity to do the fundamental measurements and the analysis of the measurements, and also has the staff which can interpret competently the results of the measurements.

If that facility were to be dropped from the budget, I think the following would happen: The Department of Architecture on the campus of the University of California at Berkeley would probably take over the facility. It would probably use it in instruction for a year or two while the previouly trained graduate students stuck around. After that it would simply stop from being used, and it would eventually be dismantled. And speaking from experience of similar things, personal experience with similar facilities in the past where the support was stopped for fiscal reasons and the facility eventually was dismantled.

Senator EVANS. If you had the same facility, the same people, the same place and the support stopped in one area, but if it was sufficiently good for those who would want to pay—in other words, when an architectural firm comes and uses it and now do they pay for the service?

Mr. BAZJANAC. They essentially do not.

Senator EVANS. Why not?

Mr. BAZJANAC. What they do is they may pay the lowest level staff for their overtime or something like that. But essentially the use of the facility is free.

Senator EVANS. Is it worth something to the designer?

Mr. BAZJANAC. I think it is worth a lot. But I do not know whether you are aware of the financial status of the architectural profession. The profit margins in architecture are so minimal that architects simply cannot afford this. Unlike some other professions where all extra work is typically funded with extra budgetary items, architectural contracts do not allow people to do anything for energy conserving, design, building, testing, or anything like that.

Clients typically presume that architects can do all of that, and it is a very unfortunate situation. It is analogous to a situation in the medical profession where you went for surgery and you expected one M.D. to do all the tasks that are done in surgery.

Senator EVANS. I agree. I always thought in the engineering profession that that was our story and it was the architects who had all the money. [Laughter.]

OK. We thank you all both very much for this contribution and I am particularly struck by some of the details here of the real potential that does lie in good design and potential energy conservation.

Mr. BAZJANAC. There is tremendous opportunity for energy conservation in buildings.

[Subsequent to the hearing Mr. Bazjanac submitted the following:]

Vladimir Bazjanac, Ph.D.
P.O.Box 4158. Berkeley. Ca 94704
(415) 548-4440

25 March 1986

Mr. K. P. Lau
Committee on Energy and Natural Resources
United States Senate
Dirksen Senate Office Building
Washington, D.C. 20510

Dear Mr. Lau:

Thank you for your help on the day of my testimony before the Subcommittee on Energy Research and Development (March 17th). When you asked after my testimony, I was not certain under which DOE programs the Windows and Daylighting, and the Building Energy Simulation Groups are funded. I have that information now.

Both groups get their funding from the Office of Buildings and Community Systems (John Millhone, Director), Building Systems Division, Building Energy Systems. The Windows and Daylighting Group is funded through Wall and Fenestration Subsystems; the Building Energy Simulation Group is funded through Performance Calculations.

I found a serious typographical error in the text I read before the Subcommittee. (At the bottom of page 3 word "extensive" was incorrectly spelled "expensive.") Please find enclosed a corrected copy of my testimony. I hope it is not too late to include the corrected text in the Record.

I would again like to thank the Subcommittee for the opportunity to testify. Please do not hesitate to call me if I can be of any further assistance.

Sincerely yours,

Vladimir Bazjanac

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Senator EVANS. Thank you very much.

The next panel is—if they will come forward—is Mr. Frank Schora, president of Hycrude from Chicago, IL; Mr. David O. Webb, senior vice president for policy and regulatory affairs of the Gas Research Institute; Dr. Bernard Lee, president, Institute of Gas Technology; Dr. John W. Larsen, chairman, American Chemical Society, Division of Fuel Chemistry; Mr. George Lawrence, president of the American Gas Association; Dr. J. Read Holland, director, school of mines and energy development, University of Alabama.

Gentlemen, if you will all take your places. All of the written testimony for each of you will be placed in the record in full. And if you would attempt to summarize your remarks in a relatively few minutes each, it gives us a chance to get to the questions which may be of benefit to the full committee.

With all that, let us start with Mr. Frank Schora.

STATEMENT OF FRANK C. SCHORA, PRESIDENT, HYCRUDE CORP.

Mr. SCHORA. Thank you, Mr. Chairman. I am Frank Schora, president of Hycrude Corp., which was formed in 1980 specifically to further efforts for production of synthetic oil from Eastern U.S. oil shales.

Eastern oil shale is a vast resource which will one day provide our Nation with an indigenous supply of synthetic oil, upon which our transportation and defense systems depend. The decline of oil prices to below $15 per barrel does not encourage the immediate development of an eastern oil shale industry by the private sector. It is imperative, however, to provide a modest level of Federal funding for eastern oil shale research programs so that in the future we will have the ability to respond to inevitable oil price increases.

Eastern oil shale has previously been considered a secondary resource. This is not so. It is a major resource. However, the eastern and western oil shale deposits are totally different, both geologically and chemically, as pointed out in DOE's own oil shale program plan. The western oil shale deposits are in general deep mined, yield 25 to 30 gallons of oil per ton when retorted by conventional technologies and are located in sparsely populated areas.

In contrast, the eastern oil shale deposits are surface mineable, require specialized retorting technologies and give oil in excess of 25 gallons per ton and are located in a region of the country which is in close proximity to process water, skilled work forces, oil refining capacity, distribution systems and, in fact, the market. These drastic differences in the nature of the two resources and the environment which surrounds them invalidate a generic research program.

In fact, work sponsored by DOE supports the concusion that little generic work can be performed in either the technology base or environmental mitigation areas. A study performed by Los Alamos concludes that eastern oil shale requires substantially different retorting technologies than the western oil shale resource in order to obtain the most economical recovery of oil.

The study shows that moving-bed hydroretorting, which was developed specifically for the eastern shale, produces oil from that shale at a substantial cost savings compared to the processes developed for operations involving western shale.

Also, the two resources are located in entirely different ecosystems. The differences in shale chemistry and the environment in which the resources are located dictate that separate environmental research activities be conducted for the eastern oil shale resource.

In recognition of the unique research needs of eastern oil shale, your subcommittee participated in the establishment of an eastern oil shale research program in fiscal year 1985 and its continuation in fiscal year 1986. As a result of the establishment of this program, several important research efforts have been initiated including:

Expansion of the data base for moving-bed hydroretorting, a process which gives oil yields for eastern shales approximately twice as high as would be obtained if conventional retorting methods were utilized; research on the beneficiation of various eastern oil shales; and the establishment of a program research and development announcement for novel concepts. It is important to maintain an eastern oil shale research program to complete these projects and make efficient use of the results obtained.

Hycrude Corp. recommends $1.5 million in fiscal year 1987 to continue the research program on expanding the data base for moving-bed hydroretorting of eastern oil shales, for investigation of fluidized-bed hydroretorting of both raw and beneficiated eastern oil shales, and for investigating the recovery of strategic metals from spent shales.

We also recommend $1.5 million to continue the Eastern Shale Beneficiation Program and to investigate the recovery of strategic metals from beneficiation effluent streams, the removal of pyritic sulfur from shale during beneficiation and subsequent microbial removal of organic sulfur, and lastly the effects of water recycling on the beneficiation process.

We recommend $2 million for the continuation and expansion of the novel concepts research program; $1 million for support research activities such as gathering thermodynamic, chemical and physical properties' data for all researchers in the area; and $1 million for environmental studies.

In conclusion, exact duplication of all western shale research in the DOE program on an eastern shale will not contribute useful data for eastern shale development. The requirements for development of eastern shale from both a retorting technology and environmental standpoint are unique. A specific program to address the research needs for eastern oil shale is mandatory. Eastern shale is a major resource.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Schora follows:]

Statement by Frank C. Schora, President
HYCRUDE Corporation
Before the Senate Energy & Natural Resources Committee
Subcommittee on Energy Research & Development
Hearings on FY'87 Authorization for the Department of Energy's
Fossil Energy Research & Development Program

March 17, 1986

Mr. Chairman and Members of the Subcommittee:

My name is Frank C. Schora. I am president of HYCRUDE Corporation, which was formed in 1980 specifically to further research and development efforts for production of synthetic crude oil from Eastern U.S. oil shales.

Eastern oil shale is a vast resource which will one day provide our nation with an indigenous supply of synthetic crude oil, upon which our transportation and defense systems depend. The decline of oil spot prices to below $15 per barrel does not encourage the immediate development of an eastern shale oil industry by the private sector. It is imperative, however, to provide a modest level of federal funding for eastern oil shale research programs so that in the future we will have the ability to respond to inevitable oil price increases. To reduce R&D efforts below present low levels will result in a loss of technical expertise in these areas which will take years to rebuild.

Eastern oil shale has previously been considered a secondary resource. The eastern and western oil shale deposits are totally different, both geologically and chemically, as pointed out in DOE's own oil shale program plan. The western oil shale deposits are in general deep mined, yield 25-30 gallons of oil per ton when retorted by conventional technologies and are located in sparsely populated areas. In contrast, the eastern oil shale deposits are surface mineable, require specialized retorting technologies to obtain oil yields in excess of 25 gallons per ton and are located in a more populous region of the country which is in close proximity to process water, skilled work forces, oil refining capacity, distribution systems and markets. These drastic differences in the nature of the two resources and the environment which surrounds them invalidate a "generic" research program.

The only studies which can be usefully performed generically are basic thermodynamic studies and the development of process simulation computer programs. In fact, work sponsored by DOE supports the conclusion that little generic work can be performed in either the Technology Base or Environmental Mitigation Areas. A study performed by Los Alamos National Laboratory concludes that Eastern oil shale requires substantially different retorting technologies than the western oil shale resouce in order to obtain the most economical recovery of oil. The study shows that moving-bed hydroretorting, which

was developed specifically for the eastern shale resource, produces oil from eastern shale at a substantial cost savings compared to the TOSCO and Paraho processes developed for operations involving western shale. Furthermore, the study concludes that much more research would have to be conducted on these "western" shale processes before they could be applied to eastern shale because of chemical differences in the resources.

In addition to the distinctly different process technologies required to fully utilize eastern and western oil shales, it must be recognized that the two resources are located in entirely different ecosystems. The differences in shale chemistry and the environment in which the resources are located dictate that separate environmental research activities also be conducted for the Eastern oil shale resource.

For example, a study performed under DOE sponsorship by Ultrasystems concludes that residuals of potential pollutants remaining in retorted shale is dependent upon the type of shale and retorting process utilized. Therefore, the tendency of retorted shales to leach and pollutants which may potentially be found in the leachates are not to be expected to be the same for eastern and western shale.

In recognition of the unique research needs of Eastern oil shale, your Subcommittee participated in the establishment of an eastern oil shale research program in FY'85, and its continuation in FY'86. As a result of the establishment of this program, several important research efforts have been initiated including:

* expansion of the data base for moving-bed hydroretorting, a process which has been proven to obtain oil yields for eastern shales approximately twice as high as would be obtained if conventional retorting methods were utilized.

* research on the beneficiation of various Eastern oil shales.

* the establishment of a Program Research and Development Announcement (PRDA) for novel concepts.

It is important to maintain an eastern oil shale research program to complete the projects listed above and to make efficient use of the results obtained in these programs.

HYCRUDE Corporation recommends $1.5 million in FY'87 to continue the research program on expanding the data base for moving-bed hydroretorting of Eastern oil shales, for investigation of fluidized-bed hydroretorting of both raw and beneficiated Eastern oil shales, and for investigating the recovery of strategic metals form spent shale.

HYCRUDE Corporation also recommends $1.5 million to continue the eastern shale beneficiation program and to investigate the recovery of strategic metals from beneficiation effluent streams, the removal of pyritic sulfur from shale during beneficiation and subsequent microbial

removal of organic sulfur, and the effects of water recycling on the beneficiation process.

HYCRUDE Corporation also recommends $2.0 million for the continuation and expansion of the novel concepts research program; $1.0 million for support research activities such as gathering thermodynamic, chemical and physical properties data for all researchers; and $1.0 million for environmental studies.

In conclusion, exact duplication of all western shale research in the DOE program on an eastern shale will not contribute useful data for eastern shale development. The requirements for development of eastern shale from both a retorting technology and environmental standpoint are unique. A specific program to address the research needs for Eastern oil shale is mandatory.

Selected Energy Research

Recommendations FY'87

PROGRAM FACT SHEET

HYCRUDE CORPORATION

Pressurized Hydroretorting Research:

Pressurized moving-bed hydroretorting is a process which demonstrates that it is possible to obtain similar oil yields for eastern and western oil shales with comparable organic carbon contents. Because conventional retorting of Eastern oil shales results in much lower oil yields than those obtained for western oil shales, the Eastern oil shales were previously considered to be a leaner resource. It was discovered, however, that Eastern oil shale is deficient in hydrogen. The addition of hydrogen at elevated pressure during retorting, such as in moving-bed hydroretorting, results in dramatically increased oil yields.

As a result of the eastern oil shale research program established by Congress in fiscal year 1985, a three-year initiative was undertaken to expand the data base for moving-bed hydroretorting of a variety of Eastern oil shales. The results of this research will provide investigators with comprehensive environmental and process data, as well as a better understanding of the relationship between oil shale chemical characteristics and moving-bed hydroretorting oil yields for a variety of Eastern oil shales. The existing project addresses improvements to the moving-bed hydroretorting process technology and/or economics by:

* investigating the gasification of raw shale fines which cannot currently be processed in the moving-bed retort. Recoverable fines, which are generated during oil shale crushing represent up to 10% of the resource.

* investigating retorting in a synthesis gas atmosphere. Utilization of synthesis gas produced by the gasification of fines could help reduce or eliminate the hydrogen requirements of retorting.

* investigating a mist generation system which will control the maximum size of oil droplets formed during retorting. This will minimize the condensation of oil droplets on shale particles and the subsequent refluxing and revaporization which results in production of gaseous hydrocarbons and reduced oil yields.

* further investigating the utilization of raw shale fines by increasing the tolerance of the moving-bed to accept fines. This work consists of research to determine the minimum particle size allowable at various solids and gas flow rates.

The results obtained in this program and a federally-sponsored eastern oil shale beneficiation program are providing direction for the development of a second generation pressurized hydroretorting technology. Pressurized hydroretorting of beneficiated oil shale produces an oil yield which is approximately four times the yield obtainable by conventional retorting of non-beneficiated oil shale. Preliminary studies indicate that the combination of beneficiation and

pressurized hydroretorting technologies has resulted in oil yields of up to 54 gallons per ton.

However, beneficiated shale, which is very finely ground, must be briquetted in order to be processed in a moving-bed technology. Pressurized hydroretorting of beneficiated shale in a fluidized-bed with an inert solids material will allow direct processing of the beneficiated shale. The inert material (sand) in the bed will aid heat transfer, promote uniform mixing, and hold the beneficiated shale in the fluidized bed for sufficient residence time.

Eastern oil shales such as Tennessee Chattanooga shale contain significant quantities of strategically important metals such as vanadium, molybdenum, nickel, chromium, and manganese. Recovery of these metals from spent oil shale could reduce our Nation's dependence upon imports of these metals while providing important environmental benefits. Techniques for recovering strategic metals from hydroretorted shale should be investigated.

HYCRUDE Corporation recommends $1.5 million in FY'87 for continuing the research program on expanding the data base for moving-bed hydroretorting of Eastern oil shales, for investigating fluidized-bed hydroretorting of both raw and beneficiated Eastern oil shales, and for investigating the recovery of strategic metals from spent shale.

Beneficiation Research:

In the beneficiation process, oil shale is finely ground and a high proportion of the inert mineral matter is separated from the organic rich portion of the shale. Beneficiation produces a greatly enriched feedstock, which can be retorted by conventional means, or by hydroretorting for even more dramatically increased oil yields. Because the feedstock is enriched, the capital cost for the retorting process is reduced.

Beneficiation can increase the number of Eastern oil shales which can be considered for retorting. In addition to the richer shales of Alabama, Indiana, Kentucky, Michigan, Ohio and Tennessee, leaner deposits in West Virginia, Illinois, Pennsylvania and New York can be enriched to the point where retorting is viable.

Fundamental research is now being conducted on beneficiation of Eastern oil shale and on moving-bed hydroretorting of beneficiated shales. A three-year research effort was initiated as a part of the eastern oil shale program mandated by Congress in FY'85. The beneficiation characteristics of various Eastern oil shales will be investigated, and the hydroretorting oil yield will be determined.

Additional research activities which should be conducted in the area of eastern oil shale beneficiation include:

* Determination of the separation characteristics of various Eastern oil shales as a function of particle size, and the efficiency of various floatation agents.

* Identification of strategic metals present in the effluent streams from the beneficiation process and determination of the technical and economic feasibility of metals recovery techniques.

* Assessment of the effects of water recycling on the beneficiation process.

* Investigation of concepts for sulfur removal from the beneficiated oil shale.

* The biological removal of nitrogen and sulfur compounds is currently being investigated for coal. The microbial removal of sulfur and nitrogen from oil shale would result in a higher quality oil product and a cleaner product gas stream. Microbial denitrification and desulfurization from the product shale oil should also be investigated.

HYCRUDE Corporation recommends $1.5 million in FY'87 for continuing oil shale beneficiation research.

Novel Concepts Research:

As a result of the eastern oil shale research program established by Congress, awards will be made to investigate novel concepts which have the potential to improve the economics or environmental impact of eastern shale retorting. The continuing support of novel concepts research will ensure the development of state-of-the-art retorting technology. Some promising novel concepts are discussed briefly below.

* By supplying the activation energy for the formation of oil from shale through radiation (at ambient temperature and pressure), it is possible to achieve a dramatic increase in oil yields with donor solvents. This concept has the potential to be integrated with beneficiation because the beneficiated product is in a slurry which can be processed directly by radiation donor solvent treatment.

* Microbial in-situ recovery of shale oil may provide a low cost method for oil recovery because the capital costs required for mining, reclamation and retorting would be eliminated.

* Replacement of the lockhopper systems from high pressure operations on solids, such as spent shale extraction from the retort, would provide substantial savings. Research on continuous techniques for the removal of solids, such as dissipating the pressure through a properly designed discharge pipe system, should be conducted.

* Catalytic retorting of oil shale can provide a technique for increasing oil yields. Doping of raw shale with catalysts has previously been shown to enhance resource

recovery. This concept needs to be investigated utilizing beneficiated oil shale where the potential for greater yield enhancements exists.

* The use of spent oil shale use for the production of cement will provide a method for utilizing the spent shale, thereby reducing spent shale disposal concerns. Preliminary testing has indicated that a viable product can be developed.

HYCRUDE Corporation recommends $2.0 million in FY'87 for continuing novel concepts research.

Support Research:

There are a variety of fundamental support research activities which should be undertaken to provide researchers with thermodynamic, chemical and physical properties data for Eastern oil shale. These data are necessary to improve the understanding of oil shale retorting and will aid in the assessment of results obtained in the other eastern oil shale research program areas. Several examples of support research activities are discussed below.

* Reaction kinetics modeling is essential to an understanding of eastern oil shale retorting and, in specific, oil loss mechanisms. Knowledge of the mechanisms of oil production will lead to new techniques for increased oil recovery from the shale. kinetics modeling can allow research to address areas such as product quality and product mix, oil production versus gas production.

* Research concerning the primary reaction products of eastern shale retorting is necessary for an understanding of the oil shale resource and effects of variations with the shale deposits on retorting products. Process research does not indicate what the primary reactions (which result in a release of oil products from the shale) are because it measures product stream components after secondary gas phase reactions. Knowledge of these primary reaction products will vastly improve the results of kinetics modeling efforts.

* Research on physical, chemical and thermodynamic shale properties should be conducted. Research to define mechanical properties such as particle integrity, crushing characteristics and thermal properties such as specific heat and heats of reaction is necessary for efficient process design.

HYCRUDE Corporation recommends $1.0 million in FY'87 for continuing Eastern oil shale support research activities.

Environmental Studies:

In addition to the environmental process research, it is necessary to conduct environmental studies. These studies should address topics such as the seasonal availability of water.

Baseline data on existing point sources of sulfur and nitrogen oxides should also be gathered.

The results of these studies will provide direction for retorting process optimization (i.e. water consumption and/or product gas desulfurization and denitrification).

HYCRUDE Corporation recommends $1.0 million in FY'87 for continuing environmental studies.

Senator EVANS. Thank you very much.
Mr. Webb.

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE

Mr. WEBB. Thank you, Senator Evans. I am David Webb, vice president of the Gas Research Institute. I appreciate the opportunity to appear before you today to present GRI's views and the fiscal year 1987 budget recommendations for gas-related research in the Department of Energy's fossil conservation and renewable programs.

GRI supports the need to reduce expenditures as Congress intended when it passed the Gramm-Rudman-Hollings bill. Therefore, the GRI recommendation is for a $121 million core program for gas-related research in the DOE budget. This recommendation is approximately 11 percent lower than the fiscal year 1986 congressional appropriations of $135 million for these same projects.

Central to GRI's recommendation is that the gas industry through GRI is planning to commit $161 million of gas industry funds to associated near-term research in these same areas, which more than matches the DOE budget recommendation.

Even though GRI is not a Government contractor and does not accept Federal funds, GRI cofunds many of its research programs with DOE. Therefore, the actions of Congress on the DOE budget do have a direct impact on the gas industry's and GRI's research programs.

In examining the fiscal year 1987 budget request, I think it is important to note that the proposed $12.1 billion DOE budget assigns $8.2 billion or two-thirds of the funds for defense activities. At the same time, new budget authority for the combined research in fossil, conservation, and renewable energy R&D is reduced by 74 percent from $717.5 million in fiscal year 1986 to only $186 million in fiscal year 1987.

To further illustrate this dramatic policy shift, the proposed DOE fiscal year 1987 budget request for the strategic defense initiative program is $604 million—three times the new budget authority for the combined fossil, conservation, and renewable solar programs.

This does not represent sound national energy policy. If Federal energy R&D funding continues this downward spiral, in a few years the Nation will once again find itself faced with rapidly rising levels of oil imports. Terminating ongoing energy R&D programs invites severe problems in meeting future energy demands.

The urgency and necessity of maintaining a viable Federal energy R&D program becomes self-evident when we examine where the United States is projected to get the major portion of its energy supplies during the next 25 years. In 1984 the United States received 90 percent of its energy from fossil fuels. GRI's projections indicates that in the year 2010, the United States will still meet more than 75 percent of its energy needs from fossil fuels. Yet, the DOE budget has proposed to assign less than 2 percent of its new budget authority in 1987 for research in fossil, conservation, and renewable energy.

National energy policy as modified by Congress has stressed and encouraged development of our Nation's energy resources and the more efficient use of energy to reduce our dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for fossil, conservation, and renewable gas-related research programs in DOE. Unfortunately, if the Nation is to have a balanced energy program again, it will require congressional initiatives to restore much of the funding that has been slashed.

National energy policy must be modified to fund development of our domestic energy sources. Within the GRI recommendation of $121 million for gas-related research, we are recommending $13 million for the fuel-cell program in the fossil energy program. Of that, $4 million would be for phosphoric acid technology development work that GRI would propose to continue to cofund with the Department of Energy.

In surface coal gasification, we are recommending $18 million with primary emphasis on gasifying our domestic eastern coal resources and emphasis on the fluidized-bed work that is ongoing in the Department of Energy.

In unconventional gas we would recommend a total of $14 million, $7 million for work to continue in the tight gas sands formations in the West, $4 million to continue work in the Devonian shales which underline nine of our Eastern States in the Appalachian regions.

In the area of conservation, Mr. Chairman, we recommend $10 million in DOE's Conservation Program for a joint program to be funded with GRI and the gas industry for heat pumps. To match the $10 million we recommend in the DOE budget, the gas industry would fund $13 million in the cofunded program.

Finally, Mr. Chairman, in the office of energy research programs in the Department of Energy in their basic energy sciences work we would recommend a redirection of $35 million to establish a viable geosciences initiative.

All projections indicate that 40 to 50 percent of our oil and gas that we will use 25 years from now are in fields that are yet to be discovered. Yet, within the Department of Energy, there is less than one percent of the budget devoted to geosciences-type related research that would lead to a better understanding of these oil and gas reservoirs.

In summary, during the past 4 years, Congress has recognized the need for viable long-term gas-related research programs in DOE and has appropriated approximately $35 million each year for these programs. The gas industry is seeking a continuation of this trend in fiscal year 1987 at a reduced level. The gas industry also is willing to cofund $161 million of this work for near-term research in these same program areas.

Thank you, Mr. Chairman. I would be glad to respond to any questions.

[The prepared statement of Mr. Webb follows:]

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
ENERGY AND NATURAL RESOURCES COMMITTEE
UNITED STATES SENATE
MARCH 17, 1986

I appreciate the opportunity to appear before you today to present the Gas Research Institute's (GRI) views and FY 1987 budget recommendations for gas-related research in the Department of Energy's (DOE) fossil, conservation, and renewables programs. GRI recognizes the importance of controlling the federal budget deficit and supports the need to reduce expenditures as Congress intended when it passed the Gramm-Rudman-Hollings bill. Therefore, GRI is recommending a $121 million core program for the gas-related research in the DOE budget. This recommendation is significantly lower than last year's gas industry recommendation and is approximately 11 percent lower than the FY 1986 congressional appropriations of $135 million for these projects. Central to GRI's recommendation is that the gas industry through GRI's research program is planning to commit $161 million to associated near-term gas-related research in 1987, which more than matches the DOE budget recommendation.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and develops financing for a cooperative research and development (R&D) program for the mutual benefit of the gas industry and its present and future customers. The R&D program is implemented through contracts with research organizations, engineering and other professional service firms, universities, energy companies, and manufacturers. Funding for the GRI R&D program is provided primarily through regulated sales of natural gas. Even though GRI is not a government contractor and does not accept federal funds, GRI cofunds and coordinates many of its research programs with DOE; therefore, the actions of Congress on the FY 1986 DOE budget deferrals and the FY 1987 DOE budget request have a direct impact on the gas industry's research program.

DOE FUNDING POLICY SHIFTS

In examining the DOE FY 1987 budget request, it is important to note that it significantly reduces spending for energy R&D and increases spending for DOE defense-related activities. The proposed $12.1 billion DOE budget request assigns $8.2 billion, or two-thirds of the funds, to defense activities. This is an increase of 14 percent over the current budget. At the same time, new budget authority for fossil, conservation, and renewable energy R&D is reduced by 74 percent from $717.5 million in FY 1986 to $185.7 million in FY 1987.

To further illustrate this dramatic policy shift, the proposed DOE FY 1987 budget request for the Strategic Defense Initiative (SDI) program is $604 million--three times the new budget authority for the fossil, conservation, and renewable energy programs combined. In fact, the $315 million increase over the FY 1986 SDI program's appropriated funds is greater than the combined new budget authority for the fossil, solar, and conservation R&D programs. This is not sound national policy. If federal energy R&D funding continues this downward spiral, in a few years the nation will once again find itself faced with rapidly rising levels of oil imports because it has not established the necessary technology base to fully develop its domestic energy resources and to use them efficiently. It should be noted

that the nation's oil import bill in 1985, although reduced significantly from 1984 levels, was still over $52 billion, and oil imports amounted to 21 percent of consumption. Therefore, terminating ongoing energy R&D programs invites severe problems in meeting future energy demand.

RATIONALE FOR FEDERAL ENERGY R&D

The urgency and necessity of maintaining a viable federal R&D program in fossil, conservation, and renewable energy becomes self-evident when we examine where the U.S. is projected to get the major portion of its energy supplies during the next 25 years. DOE's FY 1987 budget book indicates that in 1984 the U.S. received 90 percent of its energy from fossil fuels. GRI's projections (See Exhibit 1), which are consistent with DOE's, indicate that in the year 2010 the U.S. will still meet more than 75 percent of its energy needs with oil, gas, and coal. Yet DOE has proposed to assign less than 2 percent of its FY 1987 new budget authority to fossil, conservation, and renewable energy research. To fund even this severely reduced program requires the use of $67 million of fossil and $37 million of conservation R&D funds Congress appropriated just four months ago. The administration's FY 1986 deferrals will result in the termination of many programs Congress specifically approved.

National energy policy as modified by Congress has stressed and encouraged development of our nation's abundant domestic energy resources and the more efficient use of energy to reduce dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for fossil and conservation research programs in DOE. Unfortunately, if the nation is to have a balanced energy program, it will require congressional initiatives again this year. A balanced federal energy policy would establish a reasonable relationship between energy R&D funding and the actual anticipated production and use of U.S. energy resources. The DOE FY 1987 budget request ignores this relationship and does not provide a balanced energy R&D policy.

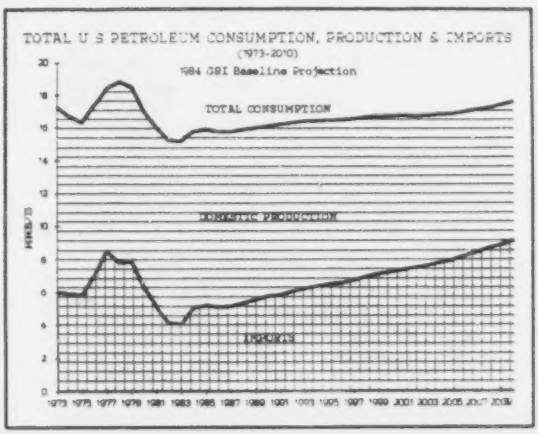
LIQUID FUELS OUTLOOK

The long-range impact of an unbalanced energy research policy that essentially ignores domestic resources is made clear when you examine the outlook for liquid fuels. The 1985 GRI Projection of U.S. Energy Supply and Demand indicates increasing total demand for liquid fuels and oil imports. The GRI projection assumes that there will be steady economic growth at average historical rates and no increases in the real dollar-denominated world price of oil and that continued conservation trends will moderate demand growth in all of the energy end-use sectors. Still, it is estimated that U.S primary energy consumption will reach nearly 102 quads in the year 2010, with petroleum contributing 35 percent (36 quads) of the total. By comparison, in 1983 the U.S. consumed 31 quads of petroleum.

Petroleum consumption is forecast to increase from 15.2 million barrels per day in 1983 to 16.7 million barrels per day in 2000. In the extended projection, petroleum consumption reaches 17.6 million barrels per day by 2010. While domestic consumption is increasing, the domestic production of crude is expected to decline throughout the projection to 7.8 million barrels per day in 2000--a reduction of nearly a million barrels per day from today's production levels. The GRI projection was prepared before the current drop in world oil prices. When it is compared to several major oil companies' forecasts, it is relatively optimistic concerning U.S. crude oil production. These oil companies expect domestic crude production to decline faster between 1983 and 2000 to around 6.5 million barrels per day in 2000.

The net result of an increasing demand for petroleum with a simultaneous decline in domestic crude production is a very large increase in dependence on foreign sources of crude. The GRI projection expects imports to increase to 9.2 million barrels per day in 2010--the greatest demand for imports since the 1977 high of 8.8 million barrels per day. The lower estimates of U.S. crude production made by some of the oil companies would result in even higher levels of imports--over 10 million barrels per day. In fact, the Interstate Oil Compact Commission recently estimated that if the current world oil price of approximately $15 per barrel is maintained for several years, the amount of domestic oil production probably will be at least 300,000 barrels per day less than current projections due to plugging and abandonment of stripper wells.

This is dramatized by the fact that the most recent U.S. rotary rig count--the leading indicator of oil and gas drilling activity--reached its lowest level since 1973 with only 1248 rigs in operation. Since at least 40 to 50 percent of the domestic oil and gas production in 2000 must come from yet-undiscovered reservoirs, if the collapse in drilling activity lasts for several years, it will result in even less domestic production and oil imports of more than 10 million barrels per day.



By the 1990s, other non-OPEC countries will also face declining production levels. As a result, the U.S. may be faced with the prospect of again relying on OPEC oil as the major source of its crude oil imports. It seems probable that once this happens, OPEC will require significant premiums in real prices to increase production to these levels. This would lead to dramatic escalations in the world price for crude near the turn of the century.

National energy policy must be modified by Congress to encourage development of ample supplies of domestic energy resources. A key element of this policy is budget actions to restore funding for critical long-term energy research in DOE. Maintaining adequate program funding is critical if the U.S. is to successfully develop the full potential of its vast domestic energy resources.

NEED FOR DOE FUNDING TO CONTINUE NATURAL GAS R&D

Natural gas will continue to maintain an important role in a highly competitive U.S. energy mix throughout the remainder of the century. (See Exhibit 2.) If funding for a viable federal/gas industry research program is continued, the technology base necessary to develop domestic supplemental gas supplies and more efficient appliances, equipment, and processes to use gas can be established. To develop this technology base requires a 10- to 15-year lead time. The current drop in world oil prices and the natural gas surplus provide a "window of opportunity." In order to provide a better R&D balance and a stable R&D environment, GRI is recommending $121 million for gas-related research in the fossil, conservation, and renewable energy programs to fund the technology base. During the past four years, Congress has recognized this need for a viable long-term gas research program in DOE and has appropriated approximately $135 million each year for these programs. The gas industry is seeking a continuation of this trend in FY 1987 at a reduced level.

GAS INDUSTRY RECOMMENDATION
DOE GAS-RELATED FUNDING
FY 1987
($ Millions)

ARTD	$ 6.0
Fuel Cells	18.0
Coal Combustion	4.0
Surface Coal Gasification	18.0
Underground Coal Gasification	5.0
Unconventional Gas	14.0
Conservation	25.0
Biofuels	14.0
Geopressured Resources Field Testing	11.0
Liquid Spill Test Facility	2.0
Natural Gas Vehicles	2.0
Thermal Energy Storage	2.0
Total	$121.0

GAS RESEARCH INSTITUTE'S 1987 BUDGET

In contrast to the DOE proposal to drastically reduce funding for long-term gas-related research, the gas industry's response to federal R&D policy directing industry to fund more of its own near-term R&D has been very impressive. While DOE has proposed about $42 million--only one-third the level of FY 1986 appropriated funds--for FY 1987 gas-related research, GRI is planning to increase its own R&D budget to $161 million in 1987 (up from $138 million in 1986)--nearly four times the DOE budget request. Clearly the gas industry has responded to federal energy R&D policy. However, an effective joint effort requires a long-term gas research program and commitment from DOE.

RECOMMENDED DOE FY 1987 GAS-RELATED RESEARCH

With the gas industry rapidly increasing its near-term research activities, it is critical for DOE to continue ongoing long-term gas research to have a viable national program. I will discuss important long-term programs in gas research that this Committee previously supported and that require continued federal funding.

FOSSIL

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Surface Coal Gasification	$41.3M	$18.0M

While the U.S. is currently experiencing a glut in natural gas supplies, in the post-2000 period, GRI projections show gas consumption declining sharply without the development of new supplemental supplies. This would occur because of a reduction in the gas available from lower-48 production. One of the most promising, abundant long-term gas supply resources is the conversion of coal to gas. For coal gasification to have a significant impact, it is necessary to validate the needed economic and design data by the late 1990s.

Of particular importance is the development of advanced processes that can use high-sulfur eastern coals and coal fines. In 1981 GRI and DOE jointly reviewed test results and technical and economic evaluations and decided to concentrate on the further development of the Westinghouse and IGT fluidized-bed processes. Continued federal support in FY 1987 of $9 million is needed for this technology development.

In addition, federal support is needed to continue research programs in improved catalysts, materials, components, and instrumentation. Significant advancements in the economies of coal gasification can result from improvements in downstream processing systems which currently comprise about one-third of the installed plant investment. A viable DOE program requires funding at levels consistent with the past two years' appropriations of $8.5 million.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Underground Coal Gasification	$4.1M	$5.0M

It is essential to complete the ongoing research efforts to verify the Controlled Retracting Injection Point (CRIP) concept for underground coal gasification to have an opportunity to make a significant contribution to gas supplies by 2000. The next logical step is to conduct R&D using this CRIP technology in producing gas from a sustained burn in a subbituminous coal seam. In addition, continued technical and economic analysis is required to determine the impact of variations in site parameters such as coal seam depth and thickness, product gas quality, linking technique, facility size, and environmental controls on gas cost. Federal support of $5 million is required. Approximately $1 million of this could be funded from the cooperative ventures R&D pool. GRI and the gas industry have $1.1 million to cofund the cooperative venture elements of this program.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Unconventional Natural Gas	$8.5M	$14.0M

Current proven gas reserves in the U.S. amount to slightly more than 200 Tcf--only 12 years of supply at today's consumption rate. However, the U.S. Geological Survey estimates that over 600 Tcf of potential U.S. natural gas reserves are still to be discovered. Unconventional gas reservoirs represent one of the best prospects for adding reserves at a competitive cost. Unconventional natural gas refers to gas contained in geologic formations that generally have not been developed by the oil and gas industry

due to the cost and difficulty of producing the gas. The National Petroleum Council's estimate of an additional 200 Tcf of reserves through development of advanced technology for just two of these unconventional gas resources--the tight lenticular formations and Devonian shales--illustrates the potential and rationale for assigning a high federal priority to this research.

The 1987 GRI unconventional natural gas program of $27 million is coordinated with the DOE R&D program. In the tight sands, so named because they are much less permeable than conventional sandstone, GRI is working on near-term research projects in blanket sands (broad continuous bands of sandstone formed from ocean sediments) while DOE is conducting work in the long-term lenticular sands (individual, lens-shaped deposits imbedded in shale rock).

GRI recommends that DOE continue research in the lenticular formations in tight sands. This research should continue the multiwell test facility activities to determine methods to pinpoint the location and shape of each sand lens and to devise methods for economically extracting the natural gas contained within them. DOE should continue the field laboratory efforts to develop improved diagnostic techniques. This will require $7 million of DOE funds. GRI's 1987 budget for near-term research in tight sands is $11.7 million and concentrates on the blanket sand formations.

DOE should continue research on recovering gas from Devonian shale. These shales are rock formations of organic-rich clay found in nine eastern states. They are typically 200 to 1000 feet thick and lie less than 8000 feet below the surface. The U.S. Geological Survey estimates that between 500 Tcf to 1100 Tcf of natural gas could be contained in the Devonian shales. However, better techniques to fracture the shale and link the shales' natural fracture systems to the wellbore must be developed to allow the gas to flow. DOE funding of $4 million is required in FY 1987 to continue the two contract efforts in recovery efficiency and installation of a reservoir testing facility. METC manages these programs, and they are coordinated with GRI's Devonian shale research which is budgeted at $7.3 million in 1987.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Fuel Cells (gas-related)	$20.3M	$18.0M

Fuel cell power systems represent a unique approach for supplying both electricity and heating requirements for multifamily residential, commercial, and light-industrial facilities. Congress has recognized this potential and added $26 million to the DOE FY 1986 budget request. Despite fuel cells' potential and the clear statement of Congressional intent, in FY 1987 DOE proposes a budget of only $5 million and also proposes to defer $22 million of the $26 million Congress added. These deferrals will cause abrupt termination of major ongoing cost-shared research projects.

In the GRI/DOE onsite phosphoric acid fuel cell program, Congress appropriated $6 million in FY 1986 that must be funded if the 50-50 cost-shared technology development is to be completed as planned. It is essential that DOE continue its long-term research programs in phosphoric acid fuel cell research. This cost-shared research is only two or three years from a logical conclusion that could result in commercial onsite power systems in the 1989-1991 time frame. GRI proposes $18 million for gas-related fuel cell research in DOE for FY 1987. This includes $4 million for technology-based research on phosphoric

acid systems, $10 million for molten carbonate systems, and $4 million for continued work in solid oxide fuel cells. GRI has corresponded with DOE and proposes to cofund the phosphoric acid fuel cell technology base research. This could be funded from the cooperative ventures pool.

In 1982 the gas industry and GRI made a major commitment to fund onsite phosphoric acid fuel cell research to offset the loss of DOE funds. GRI now has assumed the total cost of the joint DOE/GRI program to field test the 46 phosphoric acid fuel cell units. Fuel cells were installed in locations throughout the country to test the operational feasibility of the 40 kW power plants in an appropriate mix of actual utility environments. At the end of 1985, all 46 units had been installed in 15 states and had accumulated 240,000 operating hours.

FIELD TEST HOSTS

A separate four-year technology development program was initiated in late 1982 under a 50-50 cofunded GRI/DOE effort for the purpose of increasing reliability and lowering the costs of these onsite fuel cell systems. The DOE-funded elements of this four-year program require $20 million for this research with the manufacturer, the International Fuel Cells Corporation (IFC). The FY 1987 funding recommended for the DOE program is $4 million. GRI will match this funding. The DOE work concentrates on the fuel cell stack; the fuel processing system, including catalyst research; the inverter; and specialty heat exchangers. The parallel $20 million GRI-funded elements of this four-year joint program concentrate on the near-term aspects of system engineering, coolant system improvements, manufacturing techniques, and improved catalysts.

It is anticipated a commercial offering will be made in late 1986 by IFC to the gas utilities participating in the field tests. This offering, if successful, would result in a 200 kW onsite fuel cell in 1988 or 1989 for commercial market introduction.

Although phosphoric acid fuel cells show considerable promise for use in commercial, multifamily residential, and light-industrial applications, their use is limited in industrial applications that require higher-quality thermal energy. Advanced fuel cells (solid oxide) can operate at a higher temperature than phosphoric acid fuel cells (1300°F to 2000°F vs. 400°F) and, therefore, can provide higher-quality thermal energy. In addition, advanced fuel cells can achieve electrical efficiencies in the range of 50 to 70 percent. In view of the potential high efficiencies and net fuel savings that will be derived from the development of the solid oxide fuel cell, GRI recommends a budget of $4.0 million for FY 1987 for continued work in solid oxide fuel cells.

	GRI FY 1987 Recommendation
Coal Combustion/ Gas-Enhanced Flue-Gas Cleanup	$4.0M

GRI is currently working with the Energy and Environmental Research Corporation (EERC) in Irvine, California, and with the EPA to develop a dry sorbent injection technology combined with combustion modification techniques to control SO_x and NO_x emissions from coal combustion by incorporating two developing gas combustion technologies which can be applied individually or as an integrated system. One of the more promising SO_x control strategies is to inject calcium-based sorbents into the combustion chamber and capture the sulfur prior to the boiler outlet. GRI's program with EERC is to enhance the cost-effectiveness of this technology through the use of gas combustion technology.

Nitrogen oxide emissions are also considered as a contributing factor to acid deposition. The formation of NO_x during the combustion of fossil fuels can be minimized by appropriate modification of the combustion mixing process. The term "reburning" has been coined in the U.S. to refer to the process of in-house NO_x reduction by downstream injection of gas. When using gas as the reburn fuel, it appears that this technology is capable of reducing NO_x by approximately 50 to 60 percent beyond the current NSPS level achievable with low-NO_x burners.

Over the next two years, GRI plans to spend approximately $5 million to support this research and development. GRI has corresponded with DOE and has indicated a desire to demonstrate these technologies. GRI is interested in cofunding, possibly as one of the cooperative ventures.

CONSERVATION

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Gas Heat Pumps and Prime Movers	$4.2M	$10.0M

GRI and DOE are negotiating a formal joint research program for the development of one of the most promising conservation technologies--gas heat pumps. The gas heat pump not only offers increased efficiency over existing gas-fired space conditioning equipment but also provides heating and cooling in a single unit. Broad market acceptance of commercial and residential heat pumps could contribute to load leveling and reduction in peak demand for some electric utilities, thereby reducing operating costs.

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GRI has participated with DOE over the past three years in a cooperative heat pump research program. GRI has concentrated on the near-term aspects, and DOE has focused on the longer-term advanced component and engine research needed to develop a cost-competitive system. The proposed joint DOE/GRI program would include two broad categories of gas heat pump research: mechanical heat pumps and absorption heat pumps. Mechanical systems use gas engines instead of electric motors to drive a system in which a refrigerant vapor is alternately compressed and expanded in a continuous cycle. Absorption systems use the heat from gas combustion to sustain a fluid separation cycle employing evaporation and absorption.

GRI strategy calls for development of a first-generation heat pump for market introduction by 1990 and an advanced heat pump using new engine technology for introduction in the mid-1990s. Reaching these goals in a timely manner requires an expanded DOE/GRI program. Although there are many difficult technical issues to be addressed, a common barrier is first cost. The unit cost must provide a payback within five years, and the equipment must have a service life of 40,000 hours. DOE and GRI must work together on a technical basis to define a national R&D program to advance this technology.

GRI recommends the following funding profile:

ANNUAL HEAT PUMP BUDGET REQUIREMENTS SUMMARY
($ Millions)

		DOE	GRI	Total
SYSTEMS DEVELOPMENT		$ 5.5	$10.2	$15.7
Absorption	$6.1			
Stirling	5.6			
I.C. Engine	4.0			
NEW CONCEPTS EVALUATION		0.7	0.5	1.2
SUPPORTING RESEARCH		3.0	2.9	5.9
Absorption	$2.0			
Stirling	2.4			
I.C. Engine	1.0			
Other	0.5			
SYSTEMS ANALYSIS		0.8	0.8	1.6
Total Annual Budget		$10.0	$14.4	$24.4

Multiple technological options are needed for the residential market to solve the critical problems of unattended performance, first cost, and reliability. The technology concepts being pursued include double-effect and dual-cycle absorption heat pumps and heat pumps driven by reciprocating internal-combustion engines, rotary internal-combustion engines, and free-piston Stirling engines.

Development of small internal-combustion engines for use in heat pumps would have other applications such as cogeneration. Initial research has shown that the needed improvements in engine life, maintenance requirements, and controls are definitely achievable. Several attractive long-term technologies, specifically free-piston Stirling engines and free-piston internal-combustion engines, show potential. These should be developed as an element of the gas heat pump program. Research needs to be conducted in the areas of dynamic component matching, improved high-temperature materials, ceramic development and application, seal technologies, heat exchangers, use of microprocessor electronic engine controls, and high-temperature lubricants.

A viable U.S. gas heat pump and prime mover program requires a joint federal/gas industry effort with DOE funding $10 million and GRI funding $13 million to 14 million per year.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Desiccant Cooling/Refrigeration Systems	$0.0M	$2.0M

Today, the cooling needs of most small commercial buildings are being met with electric vapor compression air conditioners and heat pumps. However, in areas of the country that experience high humidity and in commercial buildings that have high internal humidity loads, the use of these systems to handle both the moisture (latent) and cooling (sensible) loads is often inefficient in terms of energy and equipment utilization. An alternate and more efficient approach is the use of an integrated gas-regenerated desiccant dehumidifier in conjunction with a smaller-capacity electric vapor compression air conditioner. Warm air from a gas burner is used to dry or regenerate the desiccant material which absorbs or removes moisture and thereby handles the latent cooling load. An electric air conditioner meets the sensible load.

GRI is field testing the concept of an integrated gas desiccant/electric air conditioner in several supermarkets. A supermarket is a good application for such a system since the operation of freezer and cooler cases reduces the sensible load and leaves approximately one-half of the air conditioning load to provide dehumidification. Current systems result in oversized air conditioners which are operated at high load factors and low evaporative coil temperatures. The result is poor efficiency and high operating costs.

While GRI concentrates on these near-term integrated gas-electric systems, DOE should initiate research on more advanced gas desiccant systems. The research should have as its goal a total desiccant cooling system (no electric cooling components) in sizes from 10 to 20 tons. Key technology improvements are needed in reducing the size and cost of the desiccant wheel and heat exchanger components. Funding of $2 million is required in FY 1987.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Building Systems/Indoor Air Quality	$1.9M	$3.0M

DOE should continue its research efforts to develop inexpensive passive monitors for measuring indoor air quality at a relatively low cost. Efforts should focus on infiltration, ventilation, and air movement in buildings. The impact of reduced air exchange rates on indoor air quality is not well understood, and investigations are required to develop an accurate and reliable data base. The DOE funding of $3 million will be supplemented by a GRI budget of $3.65 million in 1987.

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Industrial Cogeneration	$4.7M	$ 5.0M

Gas-fired cogeneration can supply both electrical and thermal energy service in a highly efficient manner. The environmental and strategic benefits of gas-fired cogeneration are also significant, since efficient use of clean-burning gas from domestic sources decreases total emissions and helps reduce unacceptable dependencies on imported petroleum fuel supplies.

Energy conversion efficiencies in the 30 percent range, typical of equipment currently dominant in industrial and electric power-producing installations, are no longer economically competitive. Cogeneration of electricity or shaft horsepower and useful heat at overall efficiencies of 70 to 80 percent are possible through a coordinated federal/industry research program. New approaches that meet the combined thermal, shaft horsepower, and electrical requirements of an industrial facility are needed.

The GRI research effort is focused on the more near-term problems of demonstrating cost-effective packaged cogeneration systems for the commercial and light-industrial markets. GRI's industrial sector R&D program, with substantial technical and financial support from industrial equipment manufacturers and end-users, is structured to overcome the present constraints facing the industrial gas consumer. GRI is currently developing packaged cogeneration systems in sizes ranging from 50 to 1000 kilowatts of electrical output. These units will have greater than 75 percent overall efficiencies at installed costs of less than $1000 per kilowatt for application in commercial buildings and multifamily dwellings. Last July an experimental packaged 500 kW cogeneration system began a one-year field test at a hospital in Houston, Texas. This packaged system, designed and built under a cost-shared GRI contract by Martin Cogeneration Systems, is just one project in GRI's effort to target cogeneration packages at major groups of applications that share similar, fairly predictable energy requirements. GRI's proposed 1987 budget contains $7.6 million for these near-term cogeneration activities.

The longer-term program DOE needs to fund is to establish and conduct a parallel research program with emphasis on developing advanced materials and advanced heat transfer and thermodynamic and microprocessor concepts. These components and concepts must then be integrated into prototype units to allow industry to evaluate the effectiveness of the systems. This R&D will improve the cost-effectiveness, efficiency, reliability, and flexibility of cogeneration systems. The result is increased cost savings and expanded potential applications for gas-fired cogeneration systems. Improved components from this DOE-sponsored research can be integrated into both first- and second-generation packaged systems. DOE funding of $5 million in FY 1987 is recommended.

RENEWABLES

	FY 1986 Appropriation	GRI FY 1987 Recommendation
Biofuels/Biomass	$18.9M	$14.0M

In addition to SNG from coal, low-cost, nonpolluting, and renewable gas supplies from biomass could be made economically available in the future with the application of engineering and agricultural sciences to the development of methane-from-biomass systems. In particular, the cost of methane from biomass could be reduced, and the biomass resource base could be expanded by the development of highly efficient systems.

The unique advantages of biomass make it an excellent candidate for many regions of the U.S. that lack conventional energy resources. GRI began a program with the University of Florida's Institute of Food and Agricultural Sciences in 1982. GRI has other related programs in the Northeast and in the Southwest. All of these are cofunded efforts. GRI anticipates that many of the results are transferable to other parts of the country. DOE should expand the regional biomass concept by providing $4 million in the FY 1987 budget.

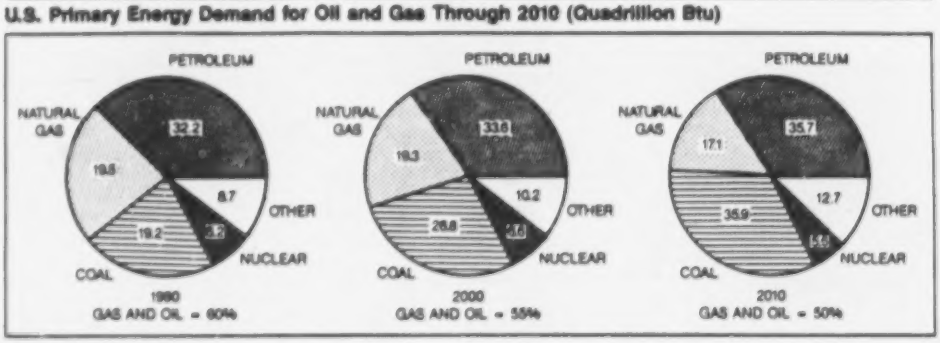
In terms of DOE-supported research, it should be centered on biotechnological advances that permit the manipulation of both the feedstock and the microorganisms used in the bioconversion process. Thus using technically proven methods of cloning for infusion of genetic material into living cells, for the ability to fix nitrogen, and for a specific conversion process, one can simultaneously adapt the biological organisms of the conversion process to produce a more efficient system. With improved biomass feedstocks through bioengineering and other techniques, a cost-competitive energy system should begin to emerge.

The gas industry recommends that $8.5 million (including $4 million for regional programs) be used for biomass conversion; $1.5 million, for waste conversion technology; and $4 million, for research on biomass growth and harvesting.

GEOSCIENCES INITIATIVE

GRI believes that the Department of Energy needs to reevaluate its basic energy research program and take a serious look at a redirection to include an expanded geosciences research initiative. For the next 25 years, GRI estimates that oil and gas will provide over 50 percent of our energy needs. Almost all of the domestic oil production by 2010 will have to come from fields and reservoirs not yet discovered and/or enhanced recovery technologies to produce the nearly two-thirds of the oil currently left in the ground. Whatever is not produced from these domestic discoveries will have to be satisfied by imported oil, primarily from OPEC nations.

U.S. Primary Energy Demand for Oil and Gas Through 2010 (Quadrillion Btu)



Despite this acknowledged demand for oil and gas, the DOE research and development budget continues to address only a small fraction of present and future demand for energy resources. The FY 1987 DOE budget provides less than 1 percent of its funds for all research projects associated with oil and gas, while 1985 consumption of oil and gas was over 60 percent of total U.S. energy consumption, and 2010 consumption will be approximately 50 percent. Therefore, a viable, cost-effective, long-term research program in the high-risk areas of geosciences devoted to understanding the basic geology and chemistry associated with the discovery and production of oil and gas is essential as part of a balanced energy research program.

GRI is proposing a redirection of $35 million within the budget for DOE's Office of Energy Research Programs ($1.8 billion in FY 1987) to establish a viable program in geosciences related to deep-source gas, methane hydrates, geopressured gas, and related generic reservoir phenomena technology.

It is quite apparent that the world and U.S. energy future over at least a 50-year time frame, and probably much longer, will depend a great deal more on our understanding of geology, geophysics, and geochemistry than on high-energy and nuclear physics and fusion energy. Basic geosciences research would greatly enhance our nation's ability to recover abundant domestic oil and gas. Therefore, DOE should start reordering its priorities without impairing those ongoing activities that are important elements in the nation's energy security by establishing a viable geosciences research program. GRI recommends the following funding profile to establish a viable geosciences program at DOE:

RECOMMENDED DOE FUNDING FOR GEOSCIENCES PROGRAM
FY 1987
($ Millions)

Geopressured Resources	$10.0
Methane Hydrates	7.0
Deep Source Gas	6.0
o Abiogenic Gas	
o Subducted Gas	
Geochemistry/Geomechanics	12.0
Total	$35.0

Funding Recommendations

INSOFAR AS SPECIFICALLY GAS-RELATED GEOSCIENCE PROGRAMS ARE CONCERNED, GRI RECOMMENDS THAT DOE CONSIDER GREATER INVOLVEMENT IN THE FOLLOWING AREAS:

GEOPRESSURED ZONE METHANE
- PHYSICAL/CHEMICAL CHARACTERISTICS OF CONTAINED WATER
- UNDERSTANDING DEEP GAS MIGRATION IN DEEP BRINE FORMATIONS
- TECHNICAL/ENVIRONMENTAL ASPECTS OF BRINE MANAGEMENT
- TECHNOLOGY TO MAXIMIZE METHANE RECOVERY

DEEP GAS
- GEOCHEMICAL/THERMODYNAMIC ASPECTS OF DEEP GAS MIGRATION
- TECHNIQUES FOR DEEP GAS DETECTION
- MODELING MODES OF DEEP GAS ENTRAPMENT

METHANE HYDRATES
- EVALUATION OF RESOURCE POTENTIAL
- IDENTIFICATION OF STRUCTURE GEOCHEMISTRY, ETC.
- CONCEPTUALIZATION OF ECONOMIC RECOVERY TECHNIQUES

GEOCHEMISTRY/GEOMECHANICS
- THERMODYNAMICS OF ROCK-FLUID SYSTEMS
- ROCK FRACTURING/IN-SITU TECTONIC STRESSES
- POROSITY, PERMEABILITY, AND DISPERSIVITY OF ROCKS
- HYDROCARBON MATURATION
- CHEMICAL PROSPECTING

SUMMARY
GRI recommends a viable, consistent long-term gas-related research budget of $121 million (see Exhibit 3) at DOE in FY 1987. This funding essentially would continue the programs Congress approved during the past three years although at reduced funding levels. It is consistent with the budget realities resulting from a large federal deficit and the Gramm-Rudman legislation since it is 11 percent less than last year's appropriations for these same programs. To balance the recommended DOE program, GRI's planned 1987 R&D budget will be $161 million. (See Exhibit 4.)

Exhibit 1

Table 1. 1985 GRI Baseline Projection of U.S. Primary Energy Consumption (Quads)

	Actual 1984[a]	1990	2000	2010
Petroleum	31.1	32.3	34.6	35.7
Gas[b,c]	17.9	18.3	18.7	16.5
(Total Gas Fuels)[d]	(18.0)	(18.4)	(19.0)	(17.3)
Coal	17.2	19.6	24.9	30.9
Nuclear	3.6	6.4	6.5	5.7
Hydro	3.7	4.0	4.0	4.0
Renewables[e]	4.3	5.1	6.7	9.4
Total	77.8	85.7	95.4	102.2

[a] *The March 1985 DOE/EIA Monthly Energy Review (MER) (published June 1985) is used as the source of 1984 historical data. Subsequent MERs included a significant shift in gas consumption from the industrial to the residential/commercial sectors. However, total gas consumption showed almost no change. The 1985 GRI Baseline Projection was based on history and reflects the unrevised data. As a result, the 1984 historical information presented in the tables reflects the earlier estimate of historical data.*

[b] *Excludes synthetic gas from petroleum and coal.*

[c] *Projected gas consumption shown in the table is consistent with the base technology assumption.*

[d] *Total gas fuels includes 0.1, 0.3, and 0.8 quad of synthetic gas from petroleum and coal in 1990, 2000, and 2010, respectively.*

[e] *Includes wood, solar, direct geothermal heat, etc.*

Table 4. 1985 GRI Baseline Projection of U.S. Energy Consumption by Sector (Quads)

	Actual 1984[a]	1990	2000	2010
Residential	9.7[b]	9.9	9.9	10.3
Commercial	5.7[b]	6.6	8.0	9.5
Industrial	24.3	27.8	31.5	32.5
Transportation	19.8	20.2	22.2	22.5
Total Delivered	59.5	64.5	71.6	74.8
Net Losses[c]	18.3	21.2	23.8	27.4
Total Primary	77.8	85.7	—95.4	102.2

[a] *The March 1985 DOE/EIA Monthly Energy Review (MER) (published June 1985) is used as the source of 1984 historical data. Subsequent MERs included a significant shift in gas consumption from the industrial to the residential/commercial sectors. However, total gas consumption showed almost no change. The 1985 GRI Baseline Projection was based on history and reflects the unrevised data. As a result, the 1984 historical information presented in the tables reflects the earlier estimate of historical data.*

[b] *Historical Energy Information Administration (EIA) statistics for 1984 do not disaggregate data for the residential and commercial sectors.*

[c] *Primarily losses in electric generation and transmission and coal gasification.*

Exhibit 2

Table 2. 1985 GRI Baseline Projection of Gas Demand by Sector (Quads)

	Actual 1984[a]	1990	2000	2010
Residential	4.5	4.3	3.9	3.6
Commercial[b]	2.4	2.8	3.7	4.5
Industrial[b]	7.4	8.2	8.4	6.1
Electric Generation[c]	3.2	2.5	2.1	2.0
Transportation[d]	0.5	0.6	0.9	1.1
Total[e,f]	18.0	18.4	19.0	17.3

[a] *The March 1985 DOE/EIA Monthly Energy Review (MER) (published June 1985) is used as the source of 1984 historical data. Subsequent MERs included a significant shift in gas consumption from the industrial to the residential/commercial sectors. However, total gas consumption showed almost no change. The 1985 GRI Baseline Projection was based on history and reflects the unrevised data. As a result, the 1984 historical information presented in the tables reflects the earlier estimate of historical data.*

[b] *Includes gas consumed in commercial and industrial cogeneration.*

[c] *Includes only gas consumed in the utility generation of electricity.*

[d] *Includes 0.3 and 0.5 quad of demand by methane vehicles in 2000 and 2010, respectively.*

[e] *Includes 0.1, 0.3, and 0.8 quad of synthetic gas from petroleum and coal in 1990, 2000, and 2010, respectively.*

[f] *Projected gas consumption shown in the table is consistent with the base technology assumption.*

Table 14. 1985 GRI Baseline Projection of Gas Supply Trends – Advanced Technology (Quads)

	1984	1990	2000	2010
Natural Gas[a]	16.6	16.5	15.1	12.1
Advanced Technology	–	(0.3)	(2.5)	(4.0)
ANGTS Gas	–	–	–	1.2
Pipeline Imports	0.8	1.2	3.1	3.9
LNG Imports	b	0.2	0.7	1.0
Coal Gas	b	b	b	0.3
SNG from Petroleum	0.1	0.1	0.2	0.2
Total Purchases	17.5	18.0	19.1	18.7
Lease and Plant Fuel	1.1	1.0	0.9	0.7
Total Supply	18.6	19.0	20.0	19.4
Less Losses and Exports	0.6	0.6	0.6	0.5
Total Demand	18.0	18.4	19.4	18.9

[a] *Includes natural gas consumed in Alaska, lower-48 conventional and unconventional natural gas.*

[b] *Less than 0.05 quad.*

Exhibit 3
GAS INDUSTRY RECOMMENDATION
DOE GAS-RELATED FUNDING
FY 1987
($ Millions)

	FY 1987 Recommendation	FY 1986 Appropriation
ARTD (Gas-Related)	$ 6.0	$ 13.1
Fuel Cells (Gas-Related)	18.0	20.3
Surface Coal Gasification	18.0	41.3
Unconventional Gas	14.0	8.5
Underground Coal Gasification (Technology Base)	4.0	4.1
Conservation (Gas-Related)	25.0	21.8
Biofuels (Gas-Related)	14.0	19.8
Geopressured Resources Field Testing	11.0	3.6
Liquid Fuel Test Facility	2.0	1.8
Natural Gas Vehicles	2.0	0.2
Thermal Energy Storage	2.0	0.0
Subtotal	$116.0	$134.5
Coal Combustion/Gas-Enhanced Flue-Gas Cleanup (Clean Coal Technology Fund)	4.0	N/A
Underground Gasification (Cooperative Ventures Pool)	1.0	N/A
Total	$121.0	$134.5

Exhibit 4
GRI FUNDING FOR ENERGY RESEARCH
($ Millions)

	GRI 1987 Planned Funding	GRI 1986 Approved Funding
FOSSIL		
Unconventional Gas	$ 26.9	$ 27.1
Coal Gasification	4.7	7.7
Fuel Cells	8.4	5.5
ARTD	8.9	5.2
Coal Combustion/Gas-Enhance Flue-Gas Cleanup	3.7	2.6
Basic Research	5.5	4.1
Subtotal	$ 58.1	$ 52.2
CONSERVATION		
Residential/Commercial	$ 52.3	$ 41.6
Industrial Utilization	22.6	18.9
Environment and Safety	2.5	2.3
Basic Research	5.1	4.2
Transport and Storage	14.9	11.9
Subtotal	$ 97.4	$ 78.9
RENEWABLES		
Biomass	$ 3.0	$ 3.9
Biological Sciences	2.7	3.2
Subtotal	$ 5.7	$ 7.1
TOTAL	$161.2	$136.2

Senator EVANS. Thank you very much, Mr. Webb.
Dr. Lee.

STATEMENT OF DR. BERNARD S. LEE, PRESIDENT, INSTITUTE OF GAS TECHNOLOGY

Dr. LEE. Thank you, Mr. Chairman. I am Bernard Lee, president of the Institute of Gas Technology, which is an organization devoted to the performance of energy R&D.

As an energy researcher, I am deeply concerned today, as you are today, that energy is no longer viewed as an important issue. The popular perception today is that energy supplies are bountiful, as if we in America had discovered some vast new energy resource. The fact is, we have not. Our domestic energy availability is not only no better than it was 10 years ago, it is worse.

The fact that the world oil prices have dropped sharply is not at all surprising, because everybody knows the Saudis can flood the market with cheap oil anytime they wish. They are pushing the price down to the point where we will once again be addicted to cheap oil while totally neglecting alternative energy development.

Oil is already our largest single import item, being three times larger than the second largest item: namely, automobiles. That balance-of-payment deficit will balloon, due to a combination of greater amounts of oil imports and reduced domestic production. Although this may not be the time for massive expenditures for development, it is certainly not the time to savage the Federal energy research effort.

There is a clear need for a sustained Federal role to maintain and build a technology base in energy. That base regrettably continues to be eroded at a rapid pace. Congress should stay the course in continuing to provide for a cost-effective Federal presence in building an energy research and technology base. It is essential for the Federal sector to maintain a stability in funding that assures a flow of technology from the laboratory to commercial use.

A level of funding close to the authorization level of fiscal year 1985 and fiscal year 1986 seems appropriate to assure that only the best research ideas are pursued. We are not looking for expansions; rather we only seek a sustaining of Federal energy research efforts consistent with due concern for the Federal budget deficit. We are convinced that the guidelines for an effective national energy policy must maximize the availability of the broadest array of domestic energy sources. Hence, our recommendations to continue support of a variety of energy sources.

We are also convinced that we must maximize the efficiency of energy utilization and the preservation of environmental integrity. Hence, our recommendation for coal utilization technologies that are free of acid rain consequences and for high-efficiency cogeneration technologies such as fuel cells.

So as part of the gas industry's position on energy R&D for fiscal year 1987 we at IGT recommend the following specific programs in which we are involved.

Under advanced research and technology development, IGT recommends $2 million for the treatment and utilization of fine coal

as a new fuel form, including biocleaning, IRM bed gasification, and burn profiles and combustion.

Under surface coal gasification, IGT recommends $3 million to test pollutant recycle and particulate removal at 500 psi pressure in an existing PDU. We also recommend $2 million for the continuation of the ash chemistry and fluidization behavior research programs which provide fundamental data necessary for a better understanding of fluidized bed coal gasification processes.

Under unconventional natural gas, IGT recommends $1 million to continue dye penetrant/CORAL analyses to better understand gas flow in tight formations.

In geopressure, geothermal energy, we recommend $4.2 million to fulfill DOE's contractual obligations in fiscal year 1987 to continue the operation of the Pleasant Bayou, Hulin, and Gladys McCall field wells which will help resolve technical issues on the production of hydrocarbons and brine, and the generation of electricity from the fluids produced.

In fuel cells, we recommend $2 million to continue the development of a contaminant-resistant molten carbonate fuel cell capable of processing gases containing sulfur and chlorine.

Under biofuels, IGT recommends $1.35 million for the joint DOE funding of an ongoing GRI program at the Walt Disney World to biologically convert municipal solids waste, industrial wastes and sewage sludge to methane gas. We recommend $2 million for the thermal chemical conversion of MSW or refuse-derived fuel in an existing high-pressured, inert-solid fluidized-bed PRU.

Thank you, Mr. Chairman, for this opportunity to appear before you and I would be happy to answer questions.

[The prepared statement of Dr. Lee follows:]

Statement of Bernard S. Lee, President
Institute of Gas Technology
Before the Senate Energy & Natural Resources Committee
Subcommittee on Energy Research & Development
Hearings on FY'87 Auhorization for the Department of Energy's
Fossil Energy Research & Development Program

March 17, 1986

Mr. Chairman and Members of the Subcommittee:

My name is Bernard S. Lee. I am President of IGT, a not-for-profit energy R&D organization in Chicago.

Having spent my entire career in energy research, I am concerned that energy is no longer viewed as an important issue today. There are those who say that funding of energy research should be cut drastically or even eliminated. They see the trends of the recent past - falling prices, supply surpluses - as irrefutable proof that forecasters who predicted the world was running out of fossil fuel resources were wrong. Yet the current energy surplus situation is no more proof that the "experts" were wrong than the supply interruptions of the '70's were proof that their predictions had suddenly come true.

Despite the recent decline in oil prices, our long- or even medium-term domestic energy availability is not one whit better than it was ten years ago; in fact, it is worse. Even before the current "free-fall" in oil prices, drilling for oil and gas in the U.S. had begun to decline rapidly. Well completions were off 20% in 1985 from the previous year and down nearly 30% from the 1981 record. The current drop parallels last year's decline in the rig count and 1986 has gotten off to a bad start with 31% fewer operating rigs than a year ago. Domestic spending on exploration and development has plummeted from almost $40 billion in 1982 to $27 billion in 1984 and dropped another 15% in 1985. If oil prices stay down for 2-3 years, investment in exploration and development will decline even more. When you consider that drilling is increasingly moving to remote and difficult locations that are expensive to develop, the magnitude of the decline becomes even more serious. All the Persian Gulf producers are doing is pushing the oil price down to the point where we will again be addicted to "cheap" oil, while totally neglecting alternative energy developments.

It's worth noting that despite the $250 billion spent by the petroleum industry on domestic exploration over the 1980-84 period, proved oil reserves declined from 30 to 28 billion barrels and the U.S. has the lowest ratio of proved oil reserves-to-production (only 9 years) of any major oil producing country. Our nation's proved gas reserves in the lower 48 states have similarly declined and are now equivalent to only 10 years production.

Several months ago, even when the universal prognosis was that oil prices would remain stable, several industry and government forecasts were published that foresaw a significant decline in domestic oil production from nearly 9 million bbl/day in 1984 to 7-8 million bbl/day by the end of the century, and a concomitant rise in imports from 30% to half of our total oil demand over the same period. Oil imports are already our single largest import item - three times greater than the second largest, automobiles - and could cost as much as $100 billion annually by 2000.

However, even these forecasts are outdated by recent events, since lower prices will boost consumption and further discourage exploration and production investments. Lower prices will also discourage private sector research and development outlays because they constrain energy companies' cash availability, and postpone the prospects of commercialization of alternative energy sources and innovative production techniques. Further, oil company research budgets have been hit in some instances by the double whammy of drastically lower crude prices, coupled with significant debt loads and redeployment of fiscal resources. They are not just cutting exploration, but in even greater measure, R&D efforts. Excellent laboratory facilities and professional research capabilities are being decimated.

The argument has been made that increased dependence on oil imports would not adversely affect our energy security, since we and our allies have switched our sources away from the Persian Gulf to non-OPEC producing areas and more "secure suppliers". But, a recent GAO report cautions against the U.S. taking for granted the ability and willingness of individual Caribbean countries to sustain or increase oil supplies to us. Mexico and Venezuela were our number one and number three crude oil suppliers. The GAO report stressed the limits both of these countries have placed on exports to the U.S., and that they have either curtailed or delayed maintenance of existing oil facilities as well as development of new fields. An increase in U.S. demand could force a resumption of Middle Eastern petroleum imports.

It's also important to keep in mind that the major non-OPEC discoveries - the North Sea, the North Slope - were the result of exploration expenditures made before 1973-74 and that similar investments are not being made today. Thus, unless major new discoveries are made outside the Persian Gulf - and this seems unlikely - we may be back on bended knee to the Persian Gulf producers. Dependence will increase not only in the U.S. and other industrialized countries but in the developing countries as well. This indeed is part of OPEC's strategy - to boost oil demand worldwide and to discourage new discovery efforts, heightening worldwide dependence on OPEC.

This nation is on a collision course between growing dependence on expensive imports and a contraction of investments in the development of viable alternatives. Although this may not be the time for massive expenditures on development, this is certainly not the time to savage the federal energy research effort. Rather, the Congress should "stay the course" in continuing to provide for a cost-effective federal presence in the support of energy research. Now is the time to channel

funding into next-generation technologies so that we have them "on the shelf" to be deployed when they are needed. But, you can't put a technology "on the shelf" for later use if there is an incomplete data base. One result of omitting critical links in technology development, is that the government will be unable to receive an adequate return on its investment in energy R&D of previous years.

We have suggested in past testimony that we need a mature national energy policy that directs a balanced and sustained program to develop appropriate technologies to meet our future energy needs. This policy should ensure a smooth flow of technology from the laboratory to commercial use. There is a need for a sustained federal role in energy research. The private sector is unlikely to continue the development of a broad array of energy technologies once federal support is interrupted, because the private sector can only concentrate on the short term in view of the arbitrary and politicized nature of the world energy arena. The private sector cannot risk its resources to strive for long-term stability when faced with the uncertainties and fluctuations of a world market controlled by different national governments.

A level of funding close to the Appropriation levels of FY'85 and FY'86 would appear to be appropriate to ensure that only the best research ideas are pursued. We do not seek expansions, rather we seek a sustaining of federal energy research efforts consistent with due concern for the federal budget deficit. Bear in mind the impact of adequate energy supplies on the Nation's economy: employment, GNP, the homeowner. We have already witnessed the impact of crude prices on the world economy. For example, with every $5 drop in the price of oil, our cost of living drops by 1%. The reverse is also true. Therefore, Congress and the Executive Branch should establish a sound energy policy and set priorities in the federal budget accordingly.

IGT has followed rigorous procedures in formulating recommendations to Congress for assistance on the budget. Each year we apply a thorough technical evaluation of the Nation's future energy requirements and the funding sources available from both government and industry. With this in mind, we are proposing a suite of research efforts which are small scale, inexpensive approaches to a variety of energy problems. As part of the gas industry position on energy RD&D for FY'87, we recommend the following specific programs in which IGT is involved:

Advanced Research and Technology Development

IGT recommends $2.0 million to study biocleaning, the IRM bed, and burn profiles to increase the utilization of fine coal as a new fuel form.

Surface Coal Gasification

IGT recommends $3.0 million to test pollutant recycle and particulate removal at 500 psi pressure in an existing PDU. IGT also recommends $2.0 million for the continuation of the ash chemistry and fluidization behavior research programs which provide fundamental data necessary for better understanding of fluidized bed coal gasification processes.

Unconventional Natural Gas

IGT recommends $1.0 million to continue dye penetrant/CORAL analyses to better understand gas flow in Devonian shales, tight gas sands, and coal seams.

Geopressured Resources

IGT recommends $4.2 million be provided for DOE to fulfill its contractual obligation in FY'87 for the continued operation of the Pleasant Bayou, Hulin, and Gladys McCall field wells to resolve technical issues on production of hydrocarbons and brine, and generation of electricity from the fluids produced.

Fuel Cells

IGT recommends $2.0 million to continue the development of a contaminant resistant molten carbonate fuel cell capable of processing gases containing sulfur and chlorine.

Biofuels

IGT recommends $1.35 million for the joint funding of an ongoing GRI program at the Walt Disney World to biologically convert municipal solids waste (MSW), industrial wastes and sewage sludge to methane gas. IGT also recommends $2.0 million for the thermal conversion of MSW or refuse-derived fuel (RDF) in the existing high-pressured, inert-solid fluidized-bed PRU.

Thermal Energy Storage

IGT recommends $2.0 million to continue research in industrial applications of the composite-phase-change TES technology by conducting tests of the composite media in a PDU, and then using the data obtained to design a cost-shared, proof-of-concept facility to be located at an industrial site.

Thank you for the opportunity to present my views. I will be happy to answer any questions.

Selected Energy Research

Recommendations FY'87

PROGRAM FACT SHEET

INSTITUTE OF GAS TECHNOLOGY

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

FINE COAL UTILIZATION

Finely ground de-ashed coal (fine coal) is a new fuel form which has great potential to improve the utilization of coal in an environmentally-responsible manner. It is therefore important to perform research on the cleaning, gasification, and combustion of fine coal.

Biocleaning.

Several processes have been developed which utilize a wet grinding process to manufacture fine coal. The resulting product, fine coal in wet slurry form, is ideally suited for microbial processing. A method for microbial removal of sulfur and nitrogen pollutants from fine coal offers significant advantages when compared to the conventional chemical methods for on-stream gas phase removal of H_2S and NH_3 from fuel gas, or SOx and NOx from flue gas. Gas phase processes that operate at elevated temperature (and possibly pressure) are susceptible to process upsets, and must be continuously operated on a real time process basis to be fully effective.

On the other hand, microbial removal (Biocleaning) of pollutants can be accomplished at low temperature and pressure and can be operated totally independent from the gasification or combustion process. In the event that a relatively minor upset occurs in the Biocleaning process, clean fuel feedstocks can be obtained from inventory with no subsequent release of pollutants. The cost of chemicals which are required for gas phase cleaning will also be eliminated.

IGT is currently researching the microbial removal of sulfur from fine coal. Most of the pyritic sulfur is physically removed during fine coal production. Removal of the organic sulfur as well may result in a product fuel which can be gasified or combusted and meet New Source Performance Standards (NSPS) without further processing. IGT recommends that this program be continued and expanded to include microbial denitrification as well.

Fine Coal Gasification:

Gasification of fine coal, which measures less than 40 microns, presents technical challenges totally different from those addressed in the gasification of raw coal. IGT recommends the investigation of a gasification process which can utilize fine coal directly: internal recirculating material, fluidized-bed (IRM bed).

Fluidized-bed processes, which are favored for coal gasification because of their high throughput and thermal efficiency can not process coal particles smaller than 40 microns. A feedstock such as fine coal, which is composed entirely of very fine particles, will not remain in the fluidized-bed for sufficient residence time required for complete gasification. IGT has developed the IRM bed which is designed to process ultra fine particles. An inert material (sand) is recirculated within the bed. This serves to hold the fine coal in the bed for sufficient residence time, while promoting mixing and efficient heat transfer. IGT recommends that a research program be conducted in an existing, process research-scale IRM bed to determine the effect of various operating parameters on the gasification of fine coal.

Fine Coal Combustion:

Burn profiles of various fine coals which have been microbially treated for desulfurization and/or denitrification should be generated to provide a comparison of coal combustion characteristics. IGT recommends a laboratory-scale research program to provide basic data required to evaluate the use of fine, microbially-treated coal for combustion.

IGT recommends $2.0 million to investigate biocleaning, the IRM bed, and burn profiles to increase the utilization of fine coal as a new fuel form.

SURFACE COAL GASIFICATION

POLLUTION ABATEMENT:

More efficient, cost effective gas processing plants for surface coal gasification are needed. Typically, over 30% of the cost of an integrated coal gasification facility is attributable to the gas purification facilities.

These facilities are composed primarily of particulate removal, waste heat recovery, gas upgrading, and pollution abatement systems. Ideally, the development of a new gas processing configuration will include efficient particulate removal and internal recycling and destruction of pollutants which remain after primary treatment. The recovery of these remaining pollutants is currently accomplished in secondary removal systems which are extremely expensive to operate because of the dilute content of the pollutants in the gas stream.

IGT has developed a concept for an Advanced Gas Treatment (AGT) system, which addresses both particulate removal and pollutant recycle. The development of this system will result in a highly efficient, dramatically simplified gas processing plant, which could be applied to

any gasifier system for any application (chemicals production or power generation).

Particulate Removal:

Gas turbines or other downstream process equipment require a very low particulate level in the gas stream to prevent shortened equipment life. Conventionally, cyclones are used to remove most of the particulate matter from the gas stream. However, cyclones alone do not provide sufficient particulate removal. IGT has tested a novel ceramic filter and has found that operation of the ceramic filter in conjunction with cyclones results in virtually complete removal of particulates. Ceramic filters must be operated cyclically to allow for filter cleaning, therefore, cycle time is an important factor in the life and cost of a ceramic filter system. Tests performed at IGT have also shown that the placement of baffles in a fluidized-bed can reduce the amount of particulates. It appears that the integration of in-bed baffles, cyclones, and ceramic filters will result in very high particulate removal efficiency and longer equipment life. IGT recommends a research program which will include modification of an existing process research unit and the collection of data on the efficiency of a particulate removal system consisting of in-bed baffles, cyclones and ceramic filters.

Pollutant Recycle:

Pollution abatement facilities for coal gasification plants include separate systems for removal of ammonia and hydrogen sulfide from the product gas, as well as systems to recover anhydrous ammonia and to convert hydrogen sulfide to a saleable by-product (usually elemental sulfur). In the case of hydrogen sulfide conversion to sulfur, a tail gas is formed which contains hydrogen sulfide and sulfur dioxide in sufficient quantity to require secondary treatment.

Conventional pollution abatement processes are expensive to operate and are often susceptible to upsets which result in unacceptable levels of sulfur and nitrogen compounds in the product gas. It is extremely desirable to develop a simpler pollution abatement system which can be used for all coal gasifiers regardless of configuration or operating pressure.

IGT has developed a concept for total recycle and destruction of all pollutants which would entirely eliminate the conventional ammonia removal, ammonia recovery, and secondary system for the removal of hydrogen sulfide and sulfur dioxide from tail gas formed during sulfur recovery.

This system consists of a water scrubber located directly after the particulate removal system and waste heat boiler.

The water scrub will remove ammonia from the product gas, and because the gas temperature is lowered, polycyclic and polynuclear aromatic compounds and light oils will also condense and be removed. The water from the scrubber will then be steam stripped to remove the pollutants, which are once again in a gaseous form much more concentrated than they were in the original coal gas stream.

This concentrated stream, together with the hydrogen sulfide- and sulfur dioxide-containing sulfur plant tail gas stream will be recycled to the gasifier at a point where reducing conditions prevail. Sulfur dioxide will be converted back to hydrogen sulfide, to be removed in the conventional sulfur removal system downstream. Ammonia, light oils, and heavier hydrocarbons will crack to lighter gases, including methane. At equilibrium, a clean gas stream which is acceptable for either power generation or chemicals production is produced.

Pollutant recycle systems previously considered have involved the recycle of sulfur pollutants only, and only at low pressure. The proposed system handles all pollutant streams; ammonia, sulfur, tars, and light oils. This greatly reduces overall plant complexity and reduces capital and operating costs.

IGT recommends $3.0 million to test pollutant recycle and particulate removal at 500 psi pressure in an existing PDU.

RESEARCH ON ASH CHEMISTRY AND FLUIDIZATION BEHAVIOR

It is important to continue basic research activities to provide the data on coal ash chemistry and fluidization behavior which is necessary input for accurate gasification models. Because gasification models are a cost effective means of simulating the effects of varying process parameters and feedstocks on gasifier performance and product quality, it is desirable to refine these models as much as possible.

IGT is currently performing research in both ash chemistry and fluidization behavior. The results of these programs provide data to all fluidized-bed gasification processes.

Ash Chemistry:

IGT is currently performing research utilizing a hot stage microscope with a video camera and a penetration viscometer designed and built by IGT expressly for this program to examine the mechanisms of ash formation for a wide variety of coal chars and to determine ash properties.

The coupling of the video camera and the hot stage microscope permits direct, visual observation of ash fusion, while the penetration viscometer provides data which aid the understanding of ash agglomeration behavior.

Fluidization Behavior:

IGT is currently operating an advanced multi-purpose research reactor to determine the behavior of both coal and ash particles in a fluidized-bed. Basic data on the interaction of the particles with fluidizing gas jets, other particles in the bed, and mechanical devices such as cyclones is being determined in this program.

IGT recommends $2.0 million in FY'87 for the continuation of the ash chemistry and fluidization behavior research programs which provide fundamental data necessary for better understanding of fluidized-bed, coal gasification processes.

UNCONVENTIONAL GAS

Geopressured/Geothermal Energy:

Geopressured/geothermal energy involves the coproduction of natural gas and hot brine. It is well known that there are thousands of TCF of methane in the ground in conjunction with geopressured reservoirs. In order to produce cost competitive natural gas, and thus attract commercial risk capital, there re technical issues that need to be resolved. The Department of Energy currently has underway as part of its geopressured resources program, a research project involving specially drilled geopressured/geothermal wells in the Texas/Louisiana Gulf Coast area. This project includes production testing coupled with scientifically sound data collection and analysis necessary to determine:

* the quantity of hydrocarbons produced with the brine

* the thermal and hydraulic energy content of the produced brine

* the best methods to produce electricity from both the hydrocarbons and the energy content of the brine

* optimum techniques to treat the brine to inhibit corrosion and scale formation, remove solids, and dispose of the produced brine in a environmentally sound manner.

This project will provide information which will be available to industry and, therefore, lower the perceived risks associated with development of this important resource.

IGT recommends $4.2 million be provided to continue funding the existing DOE contract in which three field wells, Pleasant Bayou, Hulin, and Gladys McCall, will be used to resolve technical issues on production of hydrocarbons and brine, and generation of electricity using the energy content of the produced fluids, thus reducing the risk currently inhibiting industrial development of this valuable resource.

Improved Reservoir Analysis for Tight Formations:

Tight sands, Devonian shales and coal seams are unconventional sources of natural gas which have lower permeability than conventional reservoirs. Current work has revealed that the mechanisms which control gas production in these media are very different from those found in conventional reservoirs. Additional work is required in order to understand these basic mechanisms and properly reflect them in hydraulic fracture evaluation. Such work would provide invaluable support and guidance to ongoing field test research efforts by increasing the ability to forecast reserves, and design stimulation treatments and production strategies to exploit these resources. IGT has developed specialized instruments and techniques for studying these tight reservoirs.

The dye penetration microscope technique allows the studying and photographing of the gas flow paths in the tight rocks under the actual conditions existing in the reservoir. A core sample is confined, in specially designed laboratory equipment, under stresses representative of reservoir conditions. The sample is then injected with a special fluorescent dye which, when energized, allows viewing and photographing of the flow paths in the rock. The flow paths in the tight samples are invisible under normal techniques using transmitted light.

The results from the dye penetration microscope techniques are then compared with the rock properties measurements from IGT's specially designed Computer Operated Rock Analysis Laboratory (CORAL). CORAL has been used to determine reservoir properties (porosity, pore volume compressibility, and gas permeability) of these tight reservoirs. It has shown, for example, that better understanding of the gas/liquid relative permeability behavior of these reservoir materials is required to accurately predict gas production potential.

IGT recommends that $1.0 million be provided to continue dye penetrant/CORAL analyses to better understand the mechanisms that control gas flow in tight reservoirs.

BIOFUELS

The conversion of municipal solids waste (MSW) and/or industrial wastes to gas produces a clean, useable form of energy, while simultaneously eliminating disposal problems and associated costs. Both biological and thermal conversion processes for waste gasification should be researched.

Biological Conversion:

IGT designed and is operating a biological conversion test facility which is located at Walt Disney World in Orlando, Florida. This facility currently converts a mixture of water hyacinths and sewage sludge to methane gas. This test facility should be used in a program to broaden the application of the process to a mixture composed of municipal and/or industrial wastes and sewage sludge with a low concentration of water hyacinths. The goal of the program will be to develop a process that disposes of municipal/industrial wastes and sewage sludge at a 20:1 ratio, the typical production ratio of most municipalities.

IGT recommends $1.35 million for the joint funding of an ongoing GRI research program at the Walt Disney World test facility to convert MSW, industrial wastes and sewage sludge to methane gas.

Thermal Conversion:

Technology for recovery of energy in the form of steam from burning of municipal solid waste (MSW) or refuse-derived fuel (RDF) is commercialized, but has limited application because the steam must be utilized on-site. The thermal conversion of RDF or MSW to a fuel gas is an attractive alternative.

Pressurized fluidized-bed gasification of RDF or MSW would provide high throughput, high conversion of organic carbon, and a fuel gas which can be used directly for combined cycle power generation or sold for off-site use. IGT recommends a research program to investigate pressurized, fludized-bed gasification of RDF and MSW utilizing an existing process research unit (PRU).

Because RDF is more highly processed than MSW, the program should begin by conducting parametric gasification tests with RDF to determine the effects of temperature and pressure on product gas quality, as well as an analysis of all process streams for potential pollutants. The data obtained for RDF will be helpful in directing the research for MSW, which contains inorganic materials in addition to the components found in RDF.

Feeder designs for MSW should be evaluated and gasification tests in an existing sloping grid bottom for the separation of the inorganic solids present in MSW should be conducted in an existing gasifier. The effects of seasonal variations in the composition of MSW should also be researched.

IGT recommends $2.0 million for thermal conversion of MSW or RDF in the existing high pressure inert fluidized-bed PRU.

FUEL CELLS

Contaminant Resistant Molten Carbonate Fuel Cell:

Molten carbonate fuel cells show significant performance degradation when exposed to contaminants, such as sulfur and chlorine, in the feed gas. Since it is complex and expensive to remove all such contaminants from a coal-derived feed gas, a contaminant resistant molten carbonate fuel cell would maintain a high level of performance while simultaneously decreasing the complexity and cost of the feed gas cleanup process. The optimum coal gasifier/molten carbonate fuel cell combination will minimize cleanup of the coal gas, maximize contaminant resistance of the fuel cell, and withstand occasional unexpected gasifier upsets without permanent damage to the cell. In developing such a contaminant resistant fuel cell system, IGT has determined and correlated the effects of some of these contaminants, such as hydrogen sulfide and sulfur dioxide, on cell behavior and has accumulated sufficient data to begin design and testing of different proof-of-concept configurations. Initial evaluation of one of these designs, the membrane barrier anode, indicates that it could also solve other molten carbonate fuel cell problems such as anode creep, carbonate management, and permit the use of internal reforming catalysts without degradation by the electrolyte.

IGT recommends $2.0 million to: 1) continue the development of the contaminant resistant molten carbonate fuel cell by determining the effect of chlorides on fuel cell performance and identifying and testing materials of construction resistant to contaminant-induced corrosion; 2) identify and test sulfur tolerant internal reforming catalysts; 3) initiate development of contaminant resistant molten carbonate stacks; and 4) determine the most efficient/cost effective coal gasifier/contaminant resistant molten carbonate fuel cell combination.

Thermal Energy Storage

There are numerous applications in which either the availability of high temperature thermal energy does not match the short term needs or in which the energy demand cannot be economically met by the short term supply. An efficient high-temperature direct-contact thermal energy storage and recovery system (TES) would satisfy these short term energy mismatches. Examples include:

(1) residential heating where energy stored at off-peak rates could be used for heating during peak periods, thus leveling utility loads, reducing energy costs, and minimizing the need for new power plants/distribution capacity.

(2) industrial periodic processes such as those in the brick, ceramic, glass and steel industry in which energy normally exhausted up the stack during parts of the cycle can be recovered and stored for use to meet later process requirements, thereby replacing primary fuels.

(3) solar electric power generation, either terrestrial or for space applications such as the space station and the Strategic Defense Initiative in which energy can be stored when available for use when it is dark.

(4) thermal management systems will be sued as part of any SDI space-based weapons system to control the temperatures of equipment such as refrigerators, compressors and energy weapons. High temperature TES could be used in such a thermal management system to absorb the waste heat created by such devices thus keeping them ready for reuse without fear of overheating. The energy stored in the TES would then be disposed of over a relatively long period of time without the need for excessively large radiators.

Currently high temperature industrial TES is accomplished by heating a ceramic brick during "charging" and cooling the brick to recover the heat during "discharging". The low energy storage capacity of the brick results in large, heavy, heat storage systems. Increased energy storage capacity can be achieved using phase change materials (PCM) which would be alternately melted and solidified, thus storing and releasing the energy at the desired temperature. Previous atempts at using PCM's have proven impractical because of the change in volume upon melting and solidifying, and the great resistance to heat flow through the solid material.

IGT has developed a composite TES media in which a PCM of the desired melting temperature is contained within a proous ceramic. The composite retains the PCM both in the solid and liquid phases, thus storing large amounts of heat while avoiding the problems of external volume change and poor heat transfer. When compared to ceramic bricks, the composite TES system results in 45% less weight and 35% less volume at an increase of more than 25% in efficiency. This composite TES technology can be tailored to any of the specific applications mentioned earlier. Information obtained on one application may benefit other applications.

This technology is the subject of an International Energy Agency (IEA) annex in which the U.S. government has responsibility for the development of a composite latent heat TES media and subsequent design, installation, instrumentation and operation of a full scale demonstration in the brick/ceramic industry.

IGT recommends $2.0 million to continue research on applying the composite phase change TES technology to industrial

applications, specifically by increasing the heat storage capacity of the composite, constructing a PDU, conducting tests of the composite media, and using the PDU test data to initiate design of a cost-shared, proof-of-concept facility to be located at an industrial site.

Senator EVANS. Thank you very much.
Dr. Larsen.

STATEMENT OF DR. JOHN W. LARSEN, ON BEHALF OF THE AMERICAN CHEMICAL SOCIETY

Dr. LARSEN. Mr. Chairman, thank you.

My name is John Larsen, I am professor of chemistry at Lehigh University in Bethlehem, PA, and chairman of the Division of Fuel Chemistry of the American Chemical Society. The society's board of directors has authorized my presentation of this statement before you today. I request that the complete text of this statement be entered into the hearing record.

Senator EVANS. It will be.

Dr. LARSEN. Thank you.

The American Chemical Society appreciates this opportunity to present its views on the Department of Energy's fiscal year 1987 budget request for fossil energy. The society believes the drastic cutback proposed for the fossil energy R&D budget is ill-advised. As a nation, it is easy to give short shrift to energy issues when we are not faced with crisis situations. However, the long-term needs of the United States indicate that we cannot ignore the energy area. The Society's major recommendations are summarized as follows:

Long-range coal research programs should be increased by $19 million over the budget request of $22.9 million. This should be considered a priority item in fossil energy. Other fossil energy programs should be restored to their fiscal year 1986 appropriated levels.

A substantial portion of Fossil Energy R&D is connected to coal research. The 1985 report, "Opportunities in Chemistry," states that:

> Coal is the most abundant of the fossil fuel energy sources. Estimates of recoverable supplies worldwide indicate 20 to 40 times more coal than crude oil. The contrast is even more dramatic here in the United States, where the estimates indicate 50 to 100 times more coal than crude oil. There can be no doubt that dependence on coal must increase during the next two or three decades.

Since the Fossil Energy Research and Development Program is directly responsible for producing the energy technology necessary for our future energy needs, sustained support of this R&D Program is essential.

Japan is becoming heavily involved in coal research. When coal becomes the primary energy source of choice, improved utilization of coal by Japan will result in manufacturing efficiencies and increased competition for the United States. The United States has the opportunity to stay ahead if it nurtures its coal research base.

It is indeed unfortunate that cutbacks are being proposed at a time when the opportunities for advancement have never been greater. Today, new spectroscopic techniques, chemical procedures, and theoretical understanding are available to probe the structure and reactions of noncrystalline solids.

New in situ diagnostic tools and computer modeling techniques are being advanced for accurate determination of process behavior. The potential exists for rapidly developing new knowledge that could lead to revolutionary high technology processes for utilizing

solid feedstocks in an environmentally safe and cost effective manner.

To utilize these resources properly, stable, continuous long-range R&D programs are needed to provide a sound high technology foundation on which to select and implement the process alternatives. Unfortunately, U.S. capacity for fossil fuel research has been severely reduced.

Recent mergers in the petroleum industry have resulted in substantial cutbacks in industrial research activities on alternative energy sources. Also, the present abundance of oil, the duration of which is uncertain, has led to the dismantling of many other alternative fossil fuel research efforts.

At the present levels of support, it will be difficult to maintain sound technical expertise and adequate training of new scientific and engineering talent in the technologies of coal, oil shale and tar sands. Unless corrected, this situation will jeopardize the ability of the United States to respond effectively to the next oil shortage.

The ACS is distressed at the drastic reduction proposed for the fossil energy budget. The society sets a high priority on the long-range coal research effort, and it recommends that the fiscal year 1987 fossil energy budget items for long-range coal research be increased by $19 million to $41.9 million. This would provide a 20-percent increase over the fiscal year 1986 budget levels.

The society asks that your subcommittee consider reprogramming funds from the $400 million recently established in the Clean Coal Technology Program to support these budget items. Also, the remainder of the fossil energy budget should be restored to the fiscal year 1986 program level to insure that research results can be tested on a realistic scale.

Times of economic stress are times of difficult priority choices; a time for retreat in some areas and a time for increased investment in areas that will guarantee future progress. Japan has already identified and intends to provide additional support to these same energy-related research areas. A number of U.S. scientific programs that involve much larger expenditures are under consideration. They show that the increases recommended by ACS would be modest investments but ones directly relevant to the DOE mission.

In addition, for the most efficient use of our research investment the ACS supports a competitive, merit-based peer review policy process as the primary mechanism for selection of research and instrumentation proposals for large-scale centers and facilities. The conference report on HUD-independent agencies appropriations, House Report 99-363, endorsed such a principle. It is hoped that this subcommittee will issue a similar statement of support.

In summary, the ACS supports restoration of the fossil energy budget to its fiscal year 1986 level. The importance of coal to our energy needs dictates that priority be given to long-range coal research within the fossil energy program. The society believes the cost of our recommendations are minimal compared to the many potential benefits to be derived in helping to insure a stable, long-range energy supply in the United States and in reducing our vulnerability to the uncertainties of foreign oil supplies.

Thank you.

[The prepared statement of Dr. Larsen follows:]

STATEMENT OF

JOHN W. LARSEN

on behalf of the

AMERICAN CHEMICAL SOCIETY

to the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

on

DEPARTMENT OF ENERGY FY 1987 FOSSIL ENERGY BUDGET

MARCH 17, 1986

Mr. Chairman and Members of the Subcommittee:

My name is John W. Larsen. I am Professor of Chemistry at Lehigh University, Bethlehem, Pennsylvania, and Chairman of the Division of Fuel Chemistry of the American Chemical Society. The Society's Board of Directors has authorized my presentation of this statement before you today. I request that the complete text of this statement be entered into the hearing record.

The American Chemical Society appreciates this opportunity to present its views on the Department of Energy's FY 1987 budget request for Fossil Energy. The Society believes the drastic cutback proposed for the Fossil Energy R&D budget is ill-advised. As a Nation, it is easy to give short shrift to energy issues when we are not faced with crisis situations; however, the long-term needs of the United States indicate that we cannot ignore the energy area. The Society's major recommendations are summarized as follows:

- Long-range coal research programs should be increased by $19.0 million over the budget request of $22.9 million. This should be considered a priority item in Fossil Energy.

- Other Fossil Energy programs should be restored to their FY 1986 appropriated levels.

A substantial portion of Fossil Energy R&D is connected to coal research. The 1985 Report, Opportunities in Chemistry, states that:

> Coal is the most abundant of the fossil fuel energy sources. Estimates of recoverable supplies worldwide indicate 20 to 40 times more coal than crude oil. The contrast is even more dramatic here in the United States where the estimates indicate 50 to 100 times more coal than crude oil. There can be no doubt that dependence on coal must increase during the next two or three decades...(1)

Since the Fossil Energy Research and Development program is directly responsible for producing the energy technology necessary for our future energy needs, sustained support of this R&D program is essential. Japan is becoming heavily involved in coal research. When coal becomes the primary energy source of choice, improved utilization of coal by Japan will result in manufacturing efficiencies and increased competition for the United States. The U.S. has the opportunity to stay ahead if it nurtures its coal research base.

It is indeed unfortunate that cutbacks are being proposed at a time when the opportunities for advancement have never been greater. Today, new spectroscopic techniques, chemical procedures, and theoretical understanding are available to probe the structure and reactions of non-crystalline solids.

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1. National Research Council, Opportunities in Chemistry (Washington, D.C.: National Academy Press, 1985), p. 38.

New, in situ diagnostic tools and computer modeling techniques are being advanced for accurate determination of process behavior. The potential exists for rapidly developing new knowledge that could lead to revolutionary high technology processes for utilizing solid feedstocks in an environmentally safe and cost effective manner.

To utilize these resources properly, stable, continuous long-range R&D programs are needed to provide a sound, high technology foundation on which to select and implement the process alternatives. Unfortunately, U.S. capacity for fossil fuel research has been severely reduced. Recent mergers in the petroleum industry have resulted in substantial cutbacks in industrial research activities on alternative energy sources. Also, the present abundance of oil, the duration of which is uncertain, has led to the dismantling of many other alternative fossil fuel research efforts.

At the present levels of support, it will be difficult to maintain sound technical expertise and adequate training of new scientific and engineering talent in the technologies of coal, oil shale, and tar sands. Unless corrected, this situation will jeopardize the ability of the U.S. to respond effectively to the next oil shortage.

The ACS is distressed at the drastic reduction proposed for the Fossil Energy budget. The Society sets a high priority on the long-range coal research effort and recommends that the FY 1987 Fossil Energy budget items for long-range coal research(2) be increased by $19.0 million to $41.9 million; this would provide a 20 percent increase over the FY 1986 budget levels. The Society asks that your Subcommittee consider reprogramming funds from the $400 million recently established in the Clean Coal Technology program to support these budget items. Also, the remainder of the Fossil Energy budget should be restored to the FY 1986 appropriated level to insure that research results can be tested on a realistic scale. (The accompanying Appendices I and II give a budgetary history.)

Times of economic stress are times of difficult priority choices; a time for retreat in some areas, and a time for increased investment in areas that will guarantee future progress. Japan has already identified and intends to provide additional support to these same energy-related research areas.(3) A number of U.S. scientific programs that involve much larger expenditures are under consideration. They show that the increases recommended by ACS would be modest investments, but ones directly relevant to the DOE mission.

In addition, for the most efficient use of our research investment, the ACS supports a competitive, merit-based peer-review process as the primary

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2. Coal liquefaction advanced research; surface coal gasification advanced research; and advanced research and development direct utilization, materials, and university coal research.

3. "Recommendation of the Council for Science and Technology on the 11th Inquiry titled, 'Comprehensive Fundamental Policy for Promotion of Science and Technology to Focus Current Changing Situations from the Long-term View,'" The Council for Science and Technology, Japan, November 1984.

mechanism for selection of research and instrumentation proposals for large-scale centers and facilities. The Conference Report on HUD-Independent Agencies Appropriations (H.Rpt.99-363) endorsed such a principle. It is hoped that this Subcommittee will issue a similar statement of support.

In summary, the ACS supports restoration of the Fossil Energy budget to its FY 1986 level. The importance of coal to our energy needs dictates that priority be given to long-range coal research within the Fossil Energy program. The Society believes the costs of our recommendations are minimal compared to the many potential benefits to be derived in helping to insure a stable, long-range energy supply in the U.S. and in reducing our vulnerability to the uncertainties of foreign oil supplies.

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APPENDIX I

Long-Range Coal Research Programs
[Programs under Advanced Research and Technology Development(a)]
(Dollars in Thousands)

	Surface Coal Gasification Advanced Research	Coal Liquefaction advanced Research	Direct Utilization	Materials	University Coal Research	TOTAL
1980	$14,800		$ 7,100	$ 7,000	$ 5,000	$33,900
1981	20,400		9,100	7,000	5,000	41,500
1982	18,624		10,368	7,680	5,184	41,856
1983	7,300		10,600	6,940	2,750	27,790
1984	3,650	$ 5,350	11,250	7,000	4,000	31,250
1985	3,364	5,510	9,990	7,733	4,425	31,268
1986(b)	3,379	5,157	11,262	6,899	5,622	35,054
1987(c)	968	2,620	9,415	5,860	4,000	22,863

a. Until 1986, Coal Liquefaction Advanced Research and Surface Coal Gasification Advanced Research were funded under Advanced Research and Technology Development as the Processes subprogram.

b. Enacted budget, after 4.3% reduction due to Gramm-Rudman-Hollings deficit reduction legislation.

c. Administration's Budget Request.

Source: Budget Justification Books for the Department of Energy.

APPENDIX II

Federal Support for Fossil Energy R&D Program
Fiscal Years 1971-87*
(Dollars in Millions)

ACTUAL									
1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
36	38	49	88	312	369	557	687	668	727

ACTUAL					GRAMM-RUDMAN REQUEST	
1981	1982	1983	1984	1985	1986	1987
650	408	268	278	292	284	150

* Includes funds for the Department of the Interior programs, 1971-76, transferred to DOE in 1977.

Sources:
The budget figures for 1971-81 are from the National Science Foundation "Federal R&D Funding for Energy: Fiscal Years 1971-84" (NSF 83-301). Tne 1982-87 budget figures are from the Department of Energy. The figures do not include construction, capital equipment, and program direction. The 1986 and 1987 budget figures do not include funds in the Clean Coal Technology program that was mandated by Congress.

Senator EVANS. George Lawrence.

STATEMENT OF GEORGE H. LAWRENCE, PRESIDENT, AMERICAN GAS ASSOCIATION

Mr. GEORGE LAWRENCE. Thank you, Mr. Chairman.

In the spirit of Gramm-Rudman and fiscal prudence, we too have scaled back our presentation for gas-related research by some 22 percent. It is still only a very small fraction of electric-related research which the Department of Energy pursues. Let me say that basically we are in full accord with the priorities that Mr. Webb has outlined for GRI for the gas-related research.

I would like to use my couple of minutes here today to emphasize the importance of it with particular reference at this moment, and to also express our appreciation to this committee for the fact that it has in the past recognized the contribution of gas-related research. In fiscal year 1986 it doubled the Department of Energy requests, and I am afraid the way they have cut it back so far this time we are asking you again to do the same.

But as my fellow panelists have all emphasized, there is an increasing concern now on greater reliance on energy. Your sister committees within recent days have heard some very serious testimony on the impact on our domestic exploration industry, and that might lead back very quickly to an increased reliance on OPEC and imported oil.

Your committees have also heard the growing environmental concern that we faced as we debated the acid rain issue and other air pollution problems. I think here is where gas-related research in both of these areas has such a tremendous contribution to make. We are talking about our largest source of domestic energy that is produced in this country today, natural gas.

It is 95 percent domestic. The other 5 percent we have comes from tremendous supplies from our neighbor to the north, Canada. We have a resource base of some 50 year supply in the conventional area, some 200 year supply in the area of what we call near-term new technology, tight formations, Devonian shale, free methane and coal seams, et cetera, where production is already underway converting these from new technology sources into conventional sources.

Then when we get into some of the longer-term technologies that also have been mentioned, the geopressure, hydro, methane, et cetera, we are talking about truly inexhaustible supplies of energy.

This is why I think the point Mr. Webb mentioned of the increased focus on the geosciences is so very, very timely at the moment. The Department of Energy has in its budget its basic energy sciences, a significant amount but very little of that is devoted to geology and the chemical sciences, and the geophysical sciences and the geochemical sciences.

This $35 million could be particularly relevant at the moment because it does really offer the prospect of a truly inexhaustible supply of clean domestic energy. If we do get that breakthrough, I would emphasize, too, that we could use it immediately. We have a delivery system in place. It is the most environmentally benign energy efficient in all 50 states; it goes everywhere. It is underuti-

lized today. It can be readily expanded and is a strong plus for commercializing immediately whatever research breakthroughs occur on the supply side.

The other part of the gas-related research of course is on more efficient equipment and applications. Those have been mentioned, the fuel cell, the heat pump, coal generation, new combustion technologies, all of which can make a significant contribution.

In conclusion, Mr. Chairman, let me just say again we appreciate this subcommittee's response to gas-related research needs of the past, and we think it has never been more relevant than now and for the future.

Thank you.

[The prepared statement of Mr. George Lawrence follows:]

TESTIMONY OF GEORGE H. LAWRENCE

PRESIDENT, AMERICAN GAS ASSOCIATION

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

ON THE FY 1987 DEPARTMENT OF ENERGY

RESEARCH AND DEVELOPMENT BUDGET

March 17, 1986

Mr. Chairman and Members of the Subcommittee: I am George H. Lawrence, President of the American Gas Association (A.G.A.). I am pleased to appear before you in support of natural gas-related research and development (R&D) conducted or sponsored by the Department of Energy (DOE).

A.G.A. is a national trade association consisting of nearly 300 natural gas distribution and transmission companies that serve more than 166 million consumers in all 50 states. Collectively, these companies comprise nearly 85 percent of all gas utility sales in the United States.

In recognition of the constraints on Federal spending resulting from Gramm-Rudman-Hollings, the gas industry has reconsidered its priorities for federally-sponsored gas R&D. Accordingly, A.G.A. recommends an authorization of $156 million for all DOE natural gas-related R&D in FY 1987. Our total FY 1987 recommendation reduces by 22 percent A.G.A.'s FY 1986 recommendation of $200 million. We consider this reduced level of funding for gas research in FY 1987 to be

the minimal necessary to develop and utilize future natural gas resources to their fullest potential.

DOE FUNDING FOR GAS AND GEOSCIENCES RESEARCH

Natural gas is a vital source of energy for the United States economy. For example, in 1985, estimates indicate that gas accounted for 24 percent of the primary energy consumed in the United States. Indeed, over the past 25 years, natural gas has accounted for between 24 and 33 percent of all of the primary energy consumed in the United States. Natural gas is used throughout all sectors of the economy. In 1985, gas constituted 51 percent of all end use energy consumed in the residential sector of the economy, 43 percent of all end use energy consumed in the commercial sector and 38 percent of all end use energy consumed in the industrial sector. In addition, natural gas accounts for 12 percent of all fossil energy consumed in electricity generation.

Natural gas has positive attributes which will allow it to continue to be a critical source of energy in the future. First, gas supplies are plentiful. The Potential Gas Committee, the industry group that evaluates future gas resources, has estimated that with forseeable technology and economics, the United States has approximately 981 Trillion Cubic Feet (Tcf) or about 57 years of gas supplies from conventional sources. However, many experts contend that the total amount of gas existing in conventional and

unconventional geological formations that is currently unrecoverable exceeds 100,000 Tcf. Thus, major breakthroughs in gas recovery technology enabling the recovery of one or two percent of the total gas resource base would result in doubling or tripling our 57 year recoverable gas supply. Second, natural gas is the cleanest of all fossil fuels. Gas combustion emits virtually no sulfur dioxide or particulate matter, and far fewer nitrogen oxides, nonmethane hydrocarbons and carbon monoxide than either coal or oil. Moreover, natural gas combustion does not have disposal problems such as fly ash from coal or spent nuclear fuel. Increasingly, natural gas is becoming recognized as a fuel that can be used without creating substantial environmental hazards. Third, more and more commercial and industrial users are recognizing the benefits of using natural gas. Emerging gas utilization technologies such as commercial gas cooling systems, combined cycle gas turbines, select use of gas, fuel cells and advanced cogeneration systems offer greater fuel efficiencies that will allow commercial and industrial energy users to reduce energy costs.

Although natural gas will be, in the forseeable future, a primary source of energy for the United States economy, the DOE invests relatively few of its research dollars to ensure that gas reserves will meet future gas demand. Research in the geoscientific fields of geology, geophysics and geochemistry is necessary to increase our basic

understanding of the formation and recovery of unconventional gas resources. Increased understanding of unconventional gas resources is required to achieve the technological advances that will expand the recoverable gas resource base. Indeed, production from conventional sources of gas located in the Lower-48 States is expected to decline by the year 2000. Thus, increased production from unconventional sources will be necessary to compensate for declining conventional production.

With federal assistance, the gas industry can achieve these technological advances and ultimately improve U.S. energy supply security more quickly and for substantially less money than the DOE nuclear fusion program. Even though billions of dollars have been spent on nuclear fusion research, fusion as a source of energy may not be feasible technologically until well into the 21st century.

In stark contrast, we know that, with a federal commitment of several million dollars, we can achieve technological breakthroughs in gas supply research that will expand significantly the recoverable gas resource base and improve our nation's future supply security. First, the immensity of the total gas resource base (both recoverable and unrecoverable) is well-known and well-documented. Second, recovery of much of the gas located in currently unrecoverable sources of gas is technically possible, but economically infeasible. For example, high production costs prevent the recovery of much of the gas located in tight

geological formations such as Devonian Shales and tight sands. Research breakthroughs in the techniques for recovering tight formations gas could lower production costs and increase the amount of gas that may be recovered.

To achieve the results in gas supply that we envision, DOE must fund more basic research in the geosciences. DOE currently funds a small geosciences research program within the $450 million Basic Energy Sciences (BES) program. We request that Congress direct DOE to spend, from the $441 million that DOE requests for the BES program in FY 1987, $35 million for basic geosciences research. A well-funded federal geosciences program is strongly supported by the Interstate Oil Compact Commission (IOCC), via an IOCC resolution adopted last December (attached as Exhibit A). These funds would be used not only to conduct long term, high risk geosciences research, but also to train young men and women in the geosciences field.

Advances in end use utilization of natural gas have already increased the efficiency of gas appliances and processes. Further technological advances in gas utilization will enable a single piece of equipment to provide multiple energy services with significant cost savings and efficiency gains. Further research on electrochemical processes and thermodynamics could radically change the manner in which gas is transformed into usable energy.

Increased gas use can also provide solutions to

pressing national energy and environmental problems. Our nation has several energy-related problems: (1) energy security because of oil imports; (2) air pollution resulting from sulfur oxide emissions; and (3) potential shortfalls in electricity generating capacity. The development of new, highly-efficient gas utilization technologies can solve these problems by reducing our dependence on imported oil, reducing sulfur oxide emissions and assisting electric utilities in meeting electricity demand.

SPECIFIC FUNDING RECOMMENDATIONS

UNCONVENTIONAL NATURAL GAS: $14 Million

Large amounts of gas have been identified in tight geological formations such as Devonian shales and tight sands. Devonian shales and tight sands are estimated to contain more than 1,800 Tcf and 900 Tcf of gas, respectively. Tight formations gas is produced using unconventional recovery techniques. A.G.A. estimates that favorable economic conditions and substantial investment in tight formations R&D programs could result in "incremental" production of up to 6.0 Tcf of gas annually by the year 2010, while a lesser technology program would result in an annual production rate of 1.0 Tcf by that year.

To increase production from unconventional gas resources, more research must be conducted to develop advanced stimulation techniques to fracture tight rock

formations that restrict gas flow. Current fracturing techniques induce only shallow fractures of a few hundred feet. Field testing must be conducted to refine techniques for inducing deep fractures of several thousand feet. Such techniques include foam, cryogenic, hydraulic, chemical explosive, and high energy gas fracturing. In addition, research information must be collected from field testing to establish a technological database for stimulation modeling, economic modeling and other analytical purposes.

SURFACE COAL GASIFICATION: $18 Million

Surface coal gasification is an important technology that can augment future natural gas supplies. Contemporary technologies allow significant production of gas from coal; however, high production costs have prevented coal gas from becoming a major energy source. Substantial research on advanced gasification processes is necessary for synthesized gas from coal to play a role in meeting this nation's future energy needs. Gasification techniques must be developed to accommodate high-sulfur Eastern coals and combustion-inhibiting coal "fines." Research must be conducted to develop techniques for gasifying these "fines" and liquid byproducts, and for consolidating "fines" and tars for utilization. Scientific and engineering feasibility studies of advanced gasification processes must also be conducted to develop a technological database for such processes. In addition, research must be conducted to identify the proper

treatment and disposal techniques for gasification waste byproducts.

GAS-ENHANCED FLUE GAS CLEANUP: $4 Million

Natural gas-enhanced flue gas cleanup, otherwise known as reburn, is a post-combustion pollution control method that can be used to reduce NO_x levels found in the combustion products of coal-fired electric utility or industrial boilers. Natural gas (or another fuel) is injected into the exhaust from a coal-fired boiler, creating a fuel-rich zone in which the NO_x reacts and produces free nitrogen. Air is then added to complete the combustion process. Preliminary testing indicates the reburn process using gas could easily reduce NO_2 emissions by 50 percent.

Research on the reburn process must be conducted to determine: (a) how close the reburning fuel should be relative to the combustion zone; and (b) how much time should be allowed for reburning before air is injected into the process. Funds for this research could be derived from the Clean Coal Technology appropriation.

GEOPRESSURED METHANE: $7 Million

Geopressured methane is found in either a free state or dissolved in water and trapped in sedimentary rock at higher-than-normal pressures. One of the largest geopressured areas underlies a portion of the Texas and Louisiana Gulf Coast. Estimates of the total resource in-

place range up to 100,000 Tcf; however, estimates of the amounts of gas that might ultimately be recovered range between 25 and 1,200 Tcf. Given the large in-place resource, geopressured methane could be a virtually inexhaustible source of domestic energy.

Research conducted by the DOE in the geopressured zones is focused on producing both gas and electricity from low-grade heat in the reservoir brine. The DOE should redirect its research efforts and concentrate more on recovering the vast amount of dissolved methane found in geopressured zones. In addition to the DOE's current geopressured program, the DOE should attempt novel approaches that utilize traditional engineering principles to maximize gas production and minimize brine production.

FUEL CELLS: $18 Million

Gas-fired fuel cells, in a highly efficient electrochemical process, convert the energy content of gas directly into electricity and byproduct heat. This process is much more advantageous than current electricity generation technologies, which rely upon the less efficient combustion process to generate electricity. The electrical conversion efficiency of gas-fired fuel cells is approximately one-third greater than the conversion efficiency of traditional electricity generation. Combining fuel cells with cogeneration equipment could achieve combined electrical and thermal conversion efficiency of 80

percent, compared to a conversion efficiency of 36-40 percent by the typical electric utility. Fuel cells are also environmentally benign.

More funding for phosphoric acid fuel cells is necessary for generic technology verification. Improved techniques for controlling phosphoric acid electrolyte and increasing the efficiency of DC to AC power inverters must be achieved. Research must also be conducted to develop second-generation molten carbonate fuel cells capable of processing gases containing sulfur and chlorine, as well as to develop other advanced, direct conversion concepts.

CONSERVATION: $27 Million

(1) Gas Heat Pumps ($10 million)

The operating principle of heat pumps is similar to that of an air conditioner: heat is removed from one source and pumped to its destination. By extracting heat from the outside air and transferring it to indoor space, heat pumps can actually supply more thermal energy than is contained in the fuel that they use. The heat pump's cooling effect is accomplished by reversing this process. The gas heat pump provides heating and cooling in a single unit using less energy than a conventional or high efficiency furnace uses for heating alone. Current performance estimates suggest that in heating, the gas heat pump could save one-half of the gas used in a conventional furnace and one-quarter of the gas used in a high efficiency furnace.

More research is necessary to develop highly-efficient, reliable and cost-effective gas heat pumps for residential and commercial applications. Such research must include the evaluation of promising technical approaches, fundamental research in basic heat pump processes, phenomena and materials, and research on generic component development. These activities must be integrated into overall heat pump system development and analysis. The most promising gas heat pump concepts are the double-effect absorption concept, absorption technology using fluids in novel cycles, and engine driven concepts using available internal combustion technology.

(2) Industrial Cogeneration ($5 Million)

Gas-fired cogeneration can supply both electrical and thermal energy service in a highly efficient manner. The environmental benefits of gas-fired cogeneration are also significant, since the efficient use of clean-burning gas decreases total emissions. A coordinated federal/industry cogeneration research program focusing on cogeneration of electricity or shaft horsepower and useful heat could produce overall efficiencies of 70 to 80 percent. New approaches that meet the combined thermal, shaft horsepower, and electrical requirements of an industrial facility are needed. The major problem is to develop and build advanced systems with improved operating efficiencies and ease of maintenance.

The DOE's research should focus on developing advanced

materials and advanced heat transfer, thermodynamic and microprocessor concepts. These components and concepts must then be integrated into prototype units to allow industry to evaluate the effectiveness, efficiency, reliability, and flexibility of cogeneration systems. The result is increased cost savings and expanding potential applications for gas-fired cogeneration systems. Improved components from this DOE-sponsored research can be integrated into both first- and second-generation packaged cogeneration systems.

(3) CNG Vehicles ($2 million)

Broad development of vehicles fueled by compressed natural gas would serve the national interest by improving air quality, since the emissions from CNG vehicles contain only a fraction of the nonmethane hydrocarbons, carbon monoxide, and nitrogen oxide produced by gasoline-powered vehicles. Furthermore, unlike gasoline-powered vehicles, CNG vehicles emit almost no sulfur oxides or particulate matter. Fleet use of CNG vehicles in congested cities would provide a significant benefit to those areas where air quality improvement is most critical.

Fundamental research is necessary to acquire a thorough understanding of the intricacies of gaseous fuel carburetion, manifolding, combustion, power optimization and emissions control so that natural gas can become universally accepted as a transportation fuel. Further research into novel gas compression concepts is necessary to advance the development of compressor technology. Research must also be

conducted to increase the understanding of gas storage technology, particularly the fundamental principles of natural gas adsorption, absorption, clathration and catalysis.

UNDERGROUND COAL GASIFICATION: $5 Million

Underground coal gasification is the process whereby coal is burned underground, in formation, generating a low-Btu or medium-Btu gas. The coal is gasified by drilling boreholes into the coal seam, igniting the coal and injecting air or steam and oxygen into the reaction zone. The hot gas is forced through the seam to an exit borehole where it is carried to the surface and processed to remove impurities. The gas can then be used directly as an energy source or can be upgraded to pipeline quality through catalytic methanation.

Over 80 percent of the coal resource-in-place cannot be recovered using conventional mining techniques. Underground coal gasification could increase substantially the amount of usable energy that could be recovered from the coal resource base. Moreover, underground coal gasification offers potential environmental, economic and safety advantages over conventional mining.

Extensive field testing is necessary to understand the technological basis for linking the vertical wells through the coal seam and controlling the movement of the reaction zone. Extensive environmental monitoring is also required

to analyze and control the potential contamination of surface water and local aquifers (geological formations containing water), and to control surface subsidence.

ADVANCED RESEARCH & TECHNOLOGY DEVELOPMENT: $6 Million

The Advanced Research and Technology Development program generally provides a technology base for ongoing fossil energy projects and for advanced process development. Current research needs include improving the understanding of the interactions of coal gasification processes in a fluidized-bed environment; improving the understanding of the interaction of gasification catalysts with carbon/steam and carbon/hydrogen reactions; developing advanced processes for low-cost synthesized gas; developing lower-cost acid-gas cleanup processes; and continuing efforts to assess advanced cleanup technology for alkali metals, particulates and tars.

LIQUEFIED NATURAL GAS SAFETY: $4 Million

Liquefied natural gas (LNG) is natural gas which is converted into liquid form by reducing its temperature to minus 260°F. This technique is advantageous because it permits large volumes of natural gas to be transported over great distances and terrain not otherwise suitable for pipelines. Potentially, the resource base for LNG includes any overseas gas reserves beyond those required for local consumption. However, one difficulty with transporting LNG has been that virtually no experimental data exists on the

behavior of large spills.

The Liquefied Gaseous Fuels Test Facility will allow researchers, on a user fee basis, to evaluate spills of liquefied gases, including LNG, at magnitudes far greater than has been previously possible. The research needs include investigating equipment vulnerability to natural forces, the ability of dikes to contain large spills, the advantages of in-ground storage, the behavior of spills on different surfaces and the validation of methods for preventing accidental liquefied gaseous fuels spills.

BIOMASS: $18 Million

Since the supply of organic and waste materials is virtually unlimited, supplemental methane supplies from biomass and waste conversion can add significantly to the total future gas supply picture. Developing energy from biomass also would promote the environmental benefit of productive use of currently "useless" materials. However, the quality of the gas produced and a suitable processing technique are important concerns that inhibit the widespread use of these potential gas resources.

The sources of biomass, land and marine plant matter, must be tested to determine the appropriate technology for producing high-quality gas from the resource. Because these sources vary greatly in content, the technologies must be flexible. To produce gas economically, processing techniques must be improved to increase conversion

efficiencies.

CONCLUSION

The natural gas industry recognizes that Gramm-Rudman-Hollings places severe constraints on Federal energy research dollars. Our recommendations for gas research in FY 1987 reflect these concerns. We believe that our recommendations are both necessary and prudent. If Congress adopts the gas research program supported by the gas industry, the nation will be able to bolster U.S. energy supply security and improve energy efficiency.

EXHIBIT A

RESOLUTION
BEFORE THE CONVENTION OF THE
INTERSTATE OIL COMPACT COMMISSION

WHEREAS, The United States is predicted to rely upon oil and natural gas to satisfy approximately 50 percent of its energy demand for the next 25 years, and

WHEREAS, Whatever United States demand for oil cannot be satisfied by domestic production will, in the short-term, be satisfied by imported supplies of oil, and

WHEREAS, Relatively expensive supplemental supplies of natural gas could also be subject to competition from imported oil, thereby leading to even greater dependence on the oil supplies of foreign nations, and

WHEREAS, United States hydrocarbon resources could be used to fill this future demand and thereby reduce the reliance on imported oil, and

WHEREAS, The potential domestic production of oil from non-traditional geologic formations, such as subtle traps, plus the potential additional production from domestic resources if adequate technology for enhanced oil recovery could be developed, could be over 500 billion barrels, and

WHEREAS, Many hundreds of trillion of cubic feet of gas could be recovered from such non-traditional reserves of gas as geopressured reservoirs along the United States Gulf coast, methane hydrates along the Continental Shelf off the North American coast, and from formations much deeper than state of the art drilling technology can reach, and

WHEREAS, The Department of Energy energy R&D budget is seriously imbalanced since it allows only 8.4 percent of its funds for all research projects associated with oil and gas, while 1985 consumption of oil and gas will be over 60 percent of total U.S. energy consumption, and 2010 consumption will be approximately 50 percent,

THEREFORE, The Interstate Oil Compact Commission urges the Department of Energy to promote the use of domestic resources of oil and natural gas to satisfy future demand and at the same time, to correct the severe imbalance between funding priorities in the energy R&D budget and projected United States demand for energy, by shifting sufficient funds within its planned budget to eventually provide for an adequate program in research of geoscientific issues associated with the discovery of oil and gas, amounting to approximately $50 million per year; such a newly established effort would (1) advance the state of the art in these technologies, and (2) through funding at leading universities and other institutions in the field, assure the availability of well-trained professionals in the geoscientific field which will be needed by our country to satisfy the demand for oil and gas, to the maximum extent practicable, from domestic resources.

EXHIBIT A

INTERSTATE OIL COMPACT COMMISSION

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GEORGE NIGH
Governor of Oklahoma
MARK WHITE
Governor of Texas
Joint Chairmen

W. TIMOTHY DOWD
Executive Director

December 9, 1985

Fellow IOCC Members:

The Interstate Oil Compact Commission has long been concerned with the level of federal research support devoted to geoscientific issues associated with the discovery and production of oil and gas. From a 1985 Department of Energy research and development budget of $1,859,600,000, less than $13 million was spent on geoscientific research to enhance oil and gas discovery and production. In comparison, oil and gas resources currently satisfy 60% of U.S. energy needs and are expected to satisfy 50% or more of those needs through the year 2010.

We are all aware of the new oil and gas discoveries which must be made in order to avoid over-reliance on foreign oil supplies. We are also cognizant of just how difficult it will be in the future to discover and produce the new hydrocarbon resources needed, without significant new knowledge and technology in the geosciences. Research targeting such areas as the investigation of subtle traps, new techniques for enhanced recovery, advances in the understanding of nontraditional oil and gas bearing geological formations, and deep source gas theories can help us address these needs.

Passage of the resolution now under consideration will not only demonstrate the oil and gas community's concern for adequate federal research support, but also urges fiscal responsibility through a critical redirection of federal funds (ultimately $50 million per year) rather than adding to the federal budget.

We hope you will join us in this effort.

Mark White
Governor of Texas

George Nigh
Governor of Oklahoma

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ASSOCIATES: GEORGIA · IDAHO · NORTH CAROLINA · OREGON · SOUTH CAROLINA · WASHINGTON

Senator EVANS. Thank you.
Dr. HOLLAND.

STATEMENT OF DR. J. READ HOLLAND, DIRECTOR, SCHOOL OF MINES AND ENERGY DEVELOPMENT, UNIVERSITY OF ALABAMA

Dr. HOLLAND. Thank you, Mr. Chairman.

My name is Read Holland. I am director of the School of Mines and Energy Development at the University of Alabama.

The School of Mines and Energy Development conducts and supports mineral and energy research which responds to State, regional, and national needs. In doing this, the University has over the years committed substantial funds and human resources to research aimed at development of resources and processes for improving our energy supply and our mineral supply.

We are very concerned with fossil energy, and what related activity we focus on is in the process of extraction of oil shale for the production of unconventional crude oil.

I speak to you from a background of commitment and concern. Let me depart from my prepared remarks for a moment and share a few concerns that have come up in the testimony today and in the previous testimony that I have heard relative to the Fossil Energy Program.

One thing is the $3.6 million request for oil shale research and development is really so critical that you cannot sustain a meaningful program at that level. It completely cuts out any work on the eastern oil shale, and it shows a lack of sensitivity to the role of universities on teaching and research and supplying trained manpower for future needs of the country.

The present situation of oil price declines provides us a window of opportunity for shoring up our technological base relative to fossil energy and specifically relative to eastern oil shale, so I think it is very important that we move ahead at this time and make these sorts of commitments for the future.

Let me talk to you for a moment about eastern oil shale and make some comment about the total oil shale program. There are approximately 4 billion barrels of oil in the Devonian eastern oil shales. With research you can probably extend this to a level of about 2.6 trillion barrels. If you just take the 400 billion barrels available in the reserve in the east, this would represent an 84-year domestic supply independent of any imports or conventional production. Well this is a very important area. The research we are pointing to extends the resource base and improves the economics of eastern oil shale.

We have looked at the program for the Department of Energy in the oil shale area. If you look at the 1986 program, it was $12.632 million. This provided a modest level of funding for a viable national program and provided some focus to the eastern oil shale. In 1985 this committee and other congressional committees supported a specific eastern oil shale program that was put into the budget. It was also included in the 1986 budget, but it has now been deferred by the recent deferral actions of the Department of Energy.

If you simply take the 1986 level and apply the Gramm-Rudman-Hollings reduction to it and look at what might be viable for next

year to come in and be consistent with the deficit and apply a 15-percent reduction, it gives you roughly $10.5 million for a program. We believe that the $10.5 million program will represent a minimal program that can be conducted which will maintain a steady or reduced rate of progress for development of a strong technological base.

If you are going to do this and maintain this vital core program, there are some very serious adjustments that have to be made in the budget. For example, we recommend increasing the specific eastern oil shale research to a level of $3.8 million, reducing the base technologies subprogram slightly to the level of $6 million roughly, and making a substantial reduction in the environmental mitigations subprogram.

We think that these hard choices have to be made because this provides us with the best opportunity for an assured future energy supply relative to oil shale. We think you ought to be very realistic and be very selective in your priorities in making some of these choices.

We in Alabama have a vested interest, as many Eastern States do, in oil shale because we have a very substantial reserve of eastern oil shale. Let me indicate to you, as Dr. Schora has previously but from a slightly different perspective, that there are very significant differences between eastern and western oil shales. Eastern oil shales are leaner in yield, as measured by conventional assay techniques because of their inherent hydrogen deficiency. The presence of abundant organic carbon in the eastern shales strongly indicates that you need to add hydrogen during retorting.

On the other hand, the lower carbonate content of eastern shales favors some potential oil recovery processes such as supplemental hydrogen production. This lower carbonate content also requires lower thermal input during retorting, so there are very large differences.

Further, the presence of abundant water resources and proximity to market and processing facilities, available skilled labor supply, available water supply for processing tend to offset many of the presumed economic advantages of western oil shale.

For example, we are encouraged by our work on beneficiation and coupled with hydrogen retorting on the recovery of oil from eastern shales. We think that with further research and development, the technology can be refined to the point where it seems probable that we can bring shale oil from eastern sources at $25 a barrel or less.

This projected cost is much less than the current projected cost of western shale oil at $45 to $55 a barrel. The prospect of dramatically improved of eastern shale oil justifies continuation of, and a modest increase in, the funding for research specific of eastern oil shale. It is on that basis that we recommend the $4 million or the $3.8 million for specific eastern oil shale research.

In my written testimony, I point out several programs where this should be applied, and I will skip over that. In the oil shale technology base program, we are recommending $6 million. This is a decrease from the current level of about $6.5 million. There are some areas where that program should be drastically modified. The present studies of in situ processing and fragmentation modeling

should probably be discontinued under the present budgetary circumstance.

The solids recycle chemistry and modeling can be reduced. If you do those two things, that generates about $3 million additional money or new money to reprogram. This modification would permit the Department to continue to undertake new work on innovative processes and conduct studies on other nonfuel mineral values in oil shale.

Let me point out that in oil shales, particularly the eastern oil shales, there is substantial nonfuel mineral values, such as vanadium, molybdenum, cobalt, nickel, titanium. Many of these are on the critical materials 'list.

Beneficiation of oil shale concentrates the character-enriched portion of the shale to economically attractive levels. This concentrate is also rich in many of the other mineral values. No one has undertaken a study to look at the secondary stream of product that potentially you have under these circumstances.

We think that under the levels of funding that we have recommended, that there is sufficient funding to initiate a study for recovery of all the fuel and nonfuel mineral values from the oil shale. In the environmental mitigation area subprogram, that is currently budgeted at about $3.7 million. We are suggesting that be reduced to $517,000. The reason we take this point is that we feel much of the environmental mitigation tends to be specific to the technology selected and to the sites selected. Until the technology has improved to the point that sound technical and economic decisions can be made, environmental studies should be reduced to the core level necessary to maintain a program of a generic nature relative to eastern oil shale. There are too many unanswered questions relative to sites and technologies to devote any more money to environmental mitigation at this point in time.

Let me summarize by saying that we think the $10.3 million budget for continuation in fiscal year 1987 is essential as a minimal program for oil shale, that the program should be refocused for more emphasis on the eastern oil shale, and that at this phase the recommended research program has a potential to greatly extend the resource base and dramatically improve the economics.

Thank you.

[The prepared statement of Dr. Holland follows:]

Statement by Dr. J. Read Holland, Director

The School of Mines and Energy Development

The University of Alabama

Before the Senate Subcommittee on

Energy Research and Development

Hearings on Fiscal Year 1987 Authorization for the

Department of Energy's Fossil Energy Programs

March 17, 1986

This testimony pertains to FY 1987 Department of Energy R&D Appropriations for oil shale research. The University of Alabama strongly endorses the continuation of oil shale research at a realistic level of funding and offers a plan under which an effective R&D program can be continued at a funding level below that appropriated to the Department of Energy in FY 1986.

Mr. Chairman and Members of the Subcommittee:

My name is J. Read Holland. I am Director of the School of Mines and Energy Development (SOMED) at The University of Alabama. The School of Mines and Energy Development conducts and supports mineral and energy related research which responds to state, regional, and national needs. In carrying out this mission, The University over the years has committed substantial funds and human resources to research aimed at development of resources and processes for improving the nation's energy and minerals supplies. One area of activity has focused on processing and extraction of oil shale for production of unconventional crude oil.

The oil shale deposits in the Green River formation of Colorado, Wyoming, and Utah, and the Devonian black shales in the Eastern United States constitute a vast potential resource of unconventional crude oil which in the aggregate account for an estimated oil equivalent of perhaps as much as 168 trillion barrels. The Green River deposits contain the equivalent of over 8 trillion barrels of which about 189 billion barrels can be recovered with existing technology. According to the U.S. Geological Survey, the total "known resources" of oil in the Devonian Eastern oil shales are 400 billion barrels and "probable extensions of known resources" are estimated at an additional 2.6 trillion barrels. At current national consumption levels this 400 billion barrel reserve of Eastern shale oil represents an 84 year domestic oil supply, independent of imports or other U.S. production of conventional crude oil. By application of new extraction technology now under investigation, this oil resource in the Eastern shales would increase by as much as 250 percent. Despite waxing and waning of interest in oil shale commercialization with the sharp swings in crude oil prices, there is an urgent need to continue an

innovative research program concerned with the technological development of more economical processes for extracting the oil from our domestic shales. Based on our research results, I believe we can extract Eastern shale oil at a cost of $25 per barrel or lower, thus making shale oil economically competitive.

The FY 1986 Department of Energy appropriation of $12.632 million for oil shale R&D provided a modest level of funding for the support of a viable national Western and Eastern oil shale program. Even with application of a 4 percent reduction of the appropriated funds to $12.136 million under the Gramm/Rudman/Hollings Act, this oil shale program remains viable. With the problems confronting Congress relative to the national deficit and passage of the Gramm/Rudman/Hollings Act, we recommend an FY 1987 oil shale budget of $10.316 million; this is 85% of the FY 1986 budget base. At this level the program can maintain a steady but reduced rate of progress toward development of a strong technological base. A vital core program can be maintained if appropriate adjustments are made. We recommend increasing specific Eastern Oil Shale Research and the generic Base Technology subprogram while making a substantial reduction in the Environmental Mitigation subprogram. Reduction of Environmental Mitigation was suggested in the Department of Energy FY 1987 budget request. Our suggested budget follows:

Eastern Oil Shale	$ 3.816 million
Base Technology	$ 5.983 million
Environmental Mitigation	$ .517 million
Total	$10.316 million

Supporting research to maintain a technological data base for the future is surely one of the responsibilities of the federal government. This, certainly, is a continuing requirement in the case of oil shale under the Department of Energy's current program of long-range and high risk technology development aimed at an assured future energy supply. However, such support must be selective, specific, and represent a realistic energy opportunity. Our review of the oil shale program funding adjusted to the Gramm/Rudman/Hollings Act requires a review of the priorities based on the known technology state-of-the-art.

The School of Mines and Energy Development has been deeply involved in improving our research base on Eastern oil shale, hence we offer our thoughts regarding the priorities for a meaningful oil shale R&D program. In addition to our laboratory research efforts, we continuously monitor activities pertaining to the emerging technologies, research findings, environmental concerns and economic factors that might impact utilization of Eastern shale. We acknowledge that the state of Alabama and The University of Alabama have a vested interest in the federal program on oil shale since our state is blessed with large resources of the shale. Hence, we consider development of this resource as essential to the state's economic health.

There is ample evidence indicating that significant differences exist between the Eastern and Western oil shales. For example, Eastern oil shales are leaner in oil yield, as measured by Fischer Assay, because of an inherent hydrogen deficiency. The presence of abundant organic carbon in Eastern oil shales strongly indicates a need to add hydrogen during oil recovery. On the other hand the lower carbonate content of Eastern oil shale favors some potential oil recovery processes, such as supplemental hydrogen production via the water gas shift reaction. Also this lower carbonate content of Eastern shales requires a lower thermal input during retorting. The presence of abundant water resources, proximity to the market and refineries, and available skilled labor supply, tend to offset many presumed economic advantages of Western oil shale.

We are encouraged by our recent results on recovery of oil from Eastern shales. With further research and development of the technology it now seems probable that Eastern shale oil can be produced at a cost of $25 per barrel or less. This projected cost is much less than a projected Western shale oil cost of $45 to $55 per barrel that the Department of Energy cites in their 1987 budget request. The prospect of dramatically improved economics for Eastern shale oil justifies continuation of, and a modest increase in, the funding for research specific of Eastern oil shale. We recommend a funding level of $3,816,000 for specific Eastern shale research for FY 1987. The FY 1986 Eastern oil shale appropriation is $2,000,000. This recommended funding level should be directed to:

- Continuing beneficiation and hydrogen retorting studies underway at Hycrude Corporation and the University of Alabama ($1,700,000).
- Support for innovative processing on Eastern oil shale through the Program Research and Development Announcement issued 1/15/86 by the Department of Energy ($1,116,000).
- Characterization studies of Eastern oil shale and Eastern shale oil ($500,000).
- Study of water gas shift reaction during retorting of Eastern oil shales ($500,000).

For the generic oil shale technology base we recommend $5,983,000 for FY 1987. This recommended funding represents a decrease on the generic oil shale technology from the FY 1986 base level of $6,447,000. This level will permit continuation of existing generic technology studies at Morgantown Energy Technology Center, Western Research Institute, and Lawrence Livermore National Laboratory. Further we recommend that:

- Present studies of in situ processing and fragmentation modelling be discontinued.
- Solids recycle chemistry and modelling be reduced and moved to METC.

These modifications will permit the Department of Energy to undertake new work on innovative processes and to conduct a study of the other nonfuel mineral values present in oil shale. To be specific, a generic study of the nonfuel mineral values in oil shale, such as uranium, vanadium, molybdenum, cobalt, nickel, titanium, and sulfur, should be undertaken. Beneficiation of oil shale concentrates the kerogen rich portion of the shale to economically attractive levels. This kerogen rich shale concentrate is rich in many other mineral values of interest. Some of these minerals are of great strategic importance and are on the national critical minerals list. The technical and economic feasibility of recovery or separation of these nonfuel minerals should be given careful study. For emphasis, I repeat that this recommended 1987 funding is sufficient to initiate a generic study of recovery of all fuel and nonfuel mineral values from oil shale. In addition to strategic mineral values, recovery of the heavy metals and sulfur may substantially improve the economics as well as significantly reduce the environmental risks.

Further we recommend that environmental mitigation funding be reduced from the FY 1986 appropriation of $3,689,000 to a suggested FY 1987 level of $517,000. We justify this reduction on the basis that environmental mitigation tends to be specific to the technology selected and to the production site. Until the technology is improved to the point that sound technical and economic decisions can be made, environmental studies should be reduced to a core level necessary to maintain a generic program at Morgantown Energy Technology Center. The $517,000 we recommend for FY 1987 environmental mitigation is consistent with the Department of Energy's 1987 budget request.

The University of Alabama strongly endorses continued funding of the national oil shale effort, including the specific Eastern oil shale R&D program initiated in FY 1985, and urges the appropriation of a rather modest $10.316 million budget for its continuation in FY 1987. We feel that is near the minimum level for a meaningful R&D program. Let me re-emphasize that the program we recommend begins to focus on Eastern oil shale. The recommended research program has the potential to greatly extend the resource base and dramatically improve the economics of oil shale recovery. Thank you for the opportunity to present my views to you today.

Senator EVANS. Thank you, and thank you all on the panel.

Let me ask just a few questions and indicate that we may have other questions, or other members of the subcommittee may have other questions to submit in writing to which we wish you to respond.

Mr. Webb, first for a general comment, I noticed in I do not know how many of the testimonies, at least half, maybe more, made direct reference to Gramm-Rudman-Hollings cutbacks or Gramm-Rudman-Hollings minimums. Let me say again as I did earlier in the session that Gramm-Rudman-Hollings puts no limits whatsoever on spending for fiscal year 1987. It only puts a limit on the size of the deficit at $144 billion.

Does anyone think that is too difficult? That is the fourth highest deficit in the Nation's history, and it is hardly a hard target to hit.

I think it is much more accurate to say that these are the choices the administration made when they submitted their budget to us; their belief in the priorities of energy research as related to all of the other elements that go into the budget making, including increasing taxes. So I think we ought not to blame my three colleagues who, I think, came up with really a splendid act, especially in the first half which is to set fixed targets for us to aim at rather than the flexible targets we have had in the past that got us into the trouble we are in.

The cutbacks again frankly I think will be unusual, and we probably ought not ever to see them simply because if we do the front half well we will omit the targets and there will be no cutbacks. But be that as it may, let us give the administration all the credit and none to Congress for the cutbacks in the proposal they have made to us. We will see what we can do in response, knowing that we also have all of those elements at our disposal, priority setting as well as the unenviable task of raising taxes if we think that priorities would collectively require that.

With that beginning, Mr. Webb and perhaps Mr. Lawrence as well, whoever would like to comment on it, we heard testimony earlier from Mr. Lawrence on mechanical technology of this vast market out there, a $13 billion a year market in gas heat pumps for only a $60 million investment needed to get there.

Were you that close? Is that an accurate statement of the potential market and the investment necessary to get there?

Mr. WEBB. Senator Evans, first of all the program Mr. Lawrence is referring to would be one of the projects we are proposing under this joint DOE-Gas Research Institute cofunded heat pump program. What we have proposed to the Department of Energy and before budget this year was finalized, what they were talking to us about was a 5-year program where we would put up between 55 and 60 percent of the research funds to develop these technologies.

Senator EVANS. Yes.

Mr. WEBB. I think you could probably build a prototype perhaps within 3 years. I do not think you can develop a cost competitive, if you would, initial commercial unit within 3 years. I think that is a 5 to a 7-year project.

Regarding the size of the market that he is referring to, I think he has oversimplified it in that, first of all, after we once get to the

point where—let us say we have a program in DOE until 1991. There is a couple of heat pump units that are cost competitive and ready to go on the market. At that time, some manufacturer has to step forward with about $250 million to set up a production line to manufacture these units. That is a risk capital that industry will have to bring forward at that time.

The market in heat pumps, the electric heat pump market is about 500,000 to 600,000 units a year. When you talk about 50 million units, and you talk about there is only maybe 1.5 to 2 million new homes built a year and there are so many retrofits, it is a very long-term project to get to this $13 billion market. It is not something that happens in a very short period of time.

It is a very sizeable market. There are over 40 million homes heated with gas. That is the reason the gas industry is putting in $13 million a year of our own funds into this research. But it is in fact a very high risk, long-range proposition.

Senator EVANS. Dr. Larsen, you talk about reprogramming some money from special clean coal, a special appropriation for clean coal into some of the other elements that you mentioned. I have two questions.

First, how similar are the technologies involved as they are described in the clean coal program? If you want to reprogram them, you want to reprogram them to something quite similar or compatible.

Dr. LARSEN. The technologies, I think, are quite different. You mentioned before that there is this research continuum, and our view on this is that in the clean coal technology program the funding is at the rather applied end of the continuum. These are pilot plant or demonstration units that are fairly near commercialization. We feel there is a more important Federal role farther back from the commercialization end. Basically, if the processes are very attractive, we feel the private sector will see that they get there.

Within the coal community, the very long-range fundamental work currently has to rely on the Federal Government and one or two others.

Senator EVANS. I might even agree with you as to the wisdom of that reprogramming. I am not sure that I want to be the one to go to my colleagues who got that put in the budget and suggest that it be reprogrammed out.

Dr. LARSEN. I was warned that it was going to be unpopular.

Senator EVANS. It might be popular with me, but I do not think I will go to Mr. Byrd and Mr. Warner and suggest that.

Dr. LARSEN. I tried it on Mr. Warner's staff first, and no, I would not try that.

Senator EVANS. There is a lot around here that does not go precisely according to priorities.

Dr. Lee, you mentioned a number of new technologies of things coming along. If you had to put all your money on one horse in that race as being the one that is most likely to really produce an effective impact on our energy situation, which one would it be? Which one of those do you think looks the most promising?

Dr. LEE. I hope you are not putting me into the box of putting all the eggs in one basket, which is precisely what we do not want to do.

Senator EVANS. No, as a matter of fact, I believe we ought to let the winners appear, rather than funding a broad array.

Dr. LEE. If you are looking for things that could have an impact over the shortest time in the future, I would suggest that we look at the fine coal technology, because coal is being utilized mostly in power generation and we are concerned about environmental impact. So the clean coal technology we are speaking of, fine coal is not quite ready to go into the initiative you just spoke of. That requires demonstration scale operation. We are talking about R&D to clean as much of the organic sulphur out of the coal to start with before the combustion, using existing technology which already removes most of the ash, finding advanced ways to burn the coal and do the post-cleanup as required. We feel this will give the shortest time to utilize a large resource.

So without limiting myself to all the other possibilities, let me suggest that is one.

Senator EVANS. Does anybody else wants to tackle it as to where you think the most promising things are?

Mr. GEORGE LAWRENCE. If I might, Senator, I would kind of like to pick up on a little bit of your question on the gas heat pump to Mr. Webb.

Senator EVANS. Fine.

Mr. GEORGE LAWRENCE. But in the context of your last question, because I think the contribution of the gas heat pump, there is such a thing as a desiccant system here, and the way of the conservation technology can contribute to gas cooling, and the contribution this would make to two industries and the customers of two industries, if we actually commercialize the gas cooling so the electric industry does not have to have those needle peaks, then I think it is going to be of tremendous benefit in efficiency for both the electric and the gas industry. That is on the conservation side.

On the supply side, I really think the priority goes to this focus in that $35 million to the geosciences, because that spreads across so many areas of absolutely huge potential contribution.

Senator EVANS. We are really talking more in the field of stationary energy supply both for home, commercial or industrial purposes. Would anyone like to get into that on the transportation side where we have a huge petroleum use? What alternatives appear to have the most promise out there for cutting back on petroleum use for transportation?

Mr. GEORGE LAWRENCE. If I might, Mr. Chairman, the American Gas Association today as we speak is conducting a rally for compressed natural gas vehicles from San Diego across the southern tier of the country that will end up in Richmond the middle of next month. A similar rally occured in the fall of 1984 which started in Washington and went to Seattle and San Francisco.

The contribution that natural gas-fueled vehicles can make, particularly in the commercial vehicle market—there are 16 million commercial vehicles out there that travel an average of 37 miles a day that are natural. Most of these are in the metropolitan areas and would lend themselves to CNG vehicles.

We think this is a tremendous contribution and a growing one, and we can certainly take a lesson again from our neighbors to the

north in Canada, because they are promoting this much more rapidly than we are.

Senator EVANS. That is a different kind of nonrenewable resource, however.

Mr. Schora.

Mr. SCHORA. Mr. Chairman, to revisit a little bit on eastern oil shale, this is a resource we in fact came to understand and know through the funding of the American Gas Association when in fact some of their members were interested in the use of eastern shales for the production of synthetic natural gas.

The technology led to realize that eastern shales convert very readily to liquid fuels much more easily than in fact they do to methane by proper processing. We feel that this resource, which has not I think been adequately analyzed at this point in time, which is tremendous in nature and which is in a beautifully located spot to provide for practical commercialization, as some of the problems they have in the western shale do not occur with the eastern shale.

This fuel form in some modes of refining can produce as much as 90 to 95 percent of jet fuel as opposed to kerosene and gasoline. We feel this is of tremendous import, because it avoids the problems of western shale, water problems, the environmental problems, and it is in an area where in fact I think it would fit in very well with the economy.

Some of the concerns of open cast mining I think can be addressed readily by some of the practices now underway in Germany where they go to very deep cast mining and can reconvert the land site to very useable and in fact improved farming land. We think that with adequate funding at this point in time this technology and this resource could be made ready, so that when the price of liquid fuels, the transportation fuels start to rise again, we will have a great potential resource in place and ready to be utilized by the commercial sector.

Senator EVANS. Dr. Holland, I know you would like to make a comment, but let me ask a question that fits in with that.

You mentioned $25 a barrel oil. Is that $25 a barrel figure taking into account all of the environmental concerns over mining and land restoration and all the other elements that accurately ought to be applied to any kind of energy source? We have had great trouble all the way along. I know I did sitting on the power council trying to ensure that, as we analyze the developed cost of coal versus nuclear or any other source, we had to try to make sure that we had all the costs involved.

I am curious as to what the $25 refers?

Dr. HOLLAND. I understand what you are talking about. We had our mining staff look at that very question in terms of mineability, processing, et cetera, all the elements are included in the cost associated with restoration and reclamation of land. That would include that element of the cost. I cannot tell you just exactly today what percentage of that is really reclamation and restoration, but it is in fact part of the cost.

Let me underscore what Dr. Schora had to say about eastern oil shale because it bears a vital supply of material for transportation use and for liquid fuels.

In addition to that, I would like to bring your attention to the fact that liquified natural gas has a great deal of potential as a fuel for diesel engines. We are engaged in some research and development at the moment that shows great promise in terms of using liquified natural gas, and it applies particularly to the barge users of fuel, particularly fishing trawlers and mining operations where you have concentrated use and you do not have to put in the infrastructure—the barge infrastructure for the distribution of the liquefied natural gas.

On our projections we are looking at a cost equivalent for liquefied natural gas for diesel purposes of the equivalent to about 40 cents a gallon for fuel. In the fishing trawler industry in the gulf coastal region, that amounts to about a $40,000 a year savings for a fishing trawler or shrimper trawler of 65 feet, which could be the salvation of the shrimping industry in the South and in the gulf coast region.

Senator EVANS. Can you use that liquefied natural gas in current diesel engines without modification?

Dr. HOLLAND. There is some modification that is required. The modification is fairly straightforward. We are currently building a fishing trawler using Caterpillar diesel engines to test this concept out and get a better handle on what the maintenance and service requirements might be for the operating practice. We think there is a large savings in terms of engine life because of the cleaner burning fuel.

Senator EVANS. Thank you very much. All of this has been a very interesting afternoon and a particularly interesting program from this panel.

We have lots ahead of us, and I sometimes wonder why we cheat on the research side and then wonder what we do when we are short with a whole lot greater expense. It does not seem to be a very hot set of priorities we have gotten ourself into. We will see what we can do about it.

Thank you very much.

[Whereupon, at 5 p.m., the hearing was adjourned, subject to the call of the Chair.]

APPENDIXES

APPENDIX I

Responses to Additional Committee Questions

Department of Energy
Washington, DC 20585

April 16, 1986

Honorable Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On March 17, 1986, Assistant Secretary Donna R. Fitzpatrick appeared before the Energy and Natural Resources Subcommittee on Energy Research and Development to discuss the FY 1987 budget authorization request for Conservation and Renewable Energy Programs.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Ingrid Nelson or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE MARCH 17, 1986 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

QUESTIONS FROM SENATOR DOMENICI

BUILDINGS AND COMMUNITY SYSTEMS TECHNOLOGY TRANSFER

Question 1: DOE will investigate cooperative R&D ventures with private industry consortia in order to foster increased technology transfer. Yet in Buildings and Community Systems, Analysis and Technology Transfer subprogram budget request, DOE is requesting $1 million, down from $2.6 million in FY 86. It seems the technology transfer in the energy efficiency area would have immediate return on energy conservation. Would you elaborate on DOE's justification in pushing for technology transfer and yet reducing the funding for such activities?

Answer: DOE believes that technology transfer is very important. The advantage of doing it through the cooperative R&D ventures with private industry consortia is that the Federal funds for research are leveraged by an equal or greater amount from the private sector. Technology transfer is more certain with the ventures because the private sector partners have a vested financial interest in the results.

The reduction in the referenced technology transfer line item resulted from two factors: 1) technology transfer activities are gradually (as new work begins, contracts are renewed, etc.) being incorporated more directly into the research projects; 2) the more generic technology transfer activities, such as those funded under the referenced line item, will be funded at levels commensurate with overall R&D funding and consistent with the relative priority of the activities.

QUESTIONS FROM SENATOR DOMENICI

BUILDINGS AND COMMUNITY SYSTEMS PROGRAM DIRECTION

Question 2: Your request for Program Direction is $2.4 million, a 33% reduction (45 FTE's from 71 FTE's) while the total for Buildings and Community Systems is down 62%. Why aren't FTE's reduced in proportion to the total program?

Answer: There is not always a direct correlation between program dollars and staffing levels. For example, programs not funded in FY 1987 will not stop abruptly at the end of FY 1986. Program activities will continue until funding committed during FY 1986 is exhausted. FTEs must be provided in FY 1987 to continue management of these activities until they are completed.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION R&D
INDUSTRY

Question 1: "The new technologies in the Industrial Process Efficiency Subprogram hold great promise to reduce energy required in basic industrial processes" as you put it. And yet you are requesting a 72% reduction in funding ($19.5 million to $5.5 million). Are we there already as far as all these "advanced" technologies and systems are concerned?

Answer: No, we are not. Continued development of advanced industrial processes can lead to important new contributions to energy efficiency and overall productivity. However, deficit reduction makes it imperative that we concentrate increasingly scarce government resources on the most important needs. We will be pursuing greater leverage of Federal funds through increased industry cost-sharing. Beyond that, we believe that the private sector has the incentive to develop technologies consistent with its own competitive interests.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION R&D
INDUSTRY

Question 2: The program has a -62% reduction, while FTE's are -26% (35 FTE's to 26). Why are they not in proportion?

Answer: There is not always a direct correlation between program dollars and staffing levels. For example, programs not funded in FY 1987 will not stop abruptly at the end of FY 1986. Program activities will continue until funding committed during FY 1986 is exhausted. FTEs must be provided in FY 1987 to continue management of these activities until they are completed.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION R&D
TRANSPORTATION

Question 1: You have stated in your testimony that the "transportation sector accounted for 27 percent of total energy consumption and 61 percent of the U.S. petroleum consumption (up from 51% in 1973)." It seems that we should continue the same level of R&D, if not increase the level, for more efficient use or for alternative technologies. Yet the Transportation program is sustaining a 65 percent cut. How realistically can we continue to improve efficiency and reduce petroleum consumption?

Answer: Although the transportation sector percentage of U.S. petroleum consumption has risen since 1973, most of this rise can be attributed to fuel-switching away from petroleum in other sectors. In fact, the transportation sector has made significant improvements in overall efficiency. For example, the average fuel economy of new automobiles increased from 14.2 mpg in 1973 to 26.6 mpg in 1984, an improvement of over 87 percent. However, R&D activities focused on improving energy efficiency and enhancing flexibility of fuel use options in the transportation sector remain high priority items in our budget.

Major reasons for the reduction in funding requirements for the Transportation program relate to progress in project areas. The proof-of-concept phases of programs such as the automotive gas turbine and Stirling advanced engines are being completed in FY 1986 and follow-on efforts will concentrate on less costly component technology development.

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Funding for construction of the High Temperature Materials Laboratory (HTML) at Oak Ridge National Laboratory (ORNL) will also be completed in FY 1986. In some areas, the technical feasibility screening phases will be complete, and follow-on efforts will focus on technologies with the highest potential for success. We believe the R&D activities included in the Transportation budget are those which show the greatest promise for continuing improved efficiency and reduction of petroleum consumption.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION R&D
TRANSPORTATION

Question 2: Fuel cells hold promise for transportation, we have learned from a recent hearing. What is the funding for the fuel cells program? What are the activities being funded?

Answer: No funding has been requested under the Conservation Transportation budget line item for FY 1987. However, under the Renewable Energy, Energy Storage Program, $400,000 has been requested specifically for fuel cell research to investigate higher efficiency fuel cells for applications in the transportation sector. Another $630,000 requested in that program under electrocatalysis will be used to help develop an atomic level understanding of complex electrochemical reactions of electrode surfaces and to find effective catalysts for oxygen reduction and generation in alkaline and acid electrolytes.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION R&D
MULTI-SECTOR

Question 1: On your testimony, P. 13, you have stated many great achievements from the Energy-Related Inventions Program of which I agree. Notably, 36 inventions entered the marketplace with sales of $110 million and created more than 900 direct jobs. From 1974 to 1985, the National Bureau of Standards conducted evaluations on 22,000 energy-saving inventions (2,000/year). In your FY 87 request, you only intend to support 1,000 proposed inventions. That is a 50% cut. How can DOE's actions be justified, especially when we are concerned about the U.S. competitiveness with other countries? We should encourage and assist inventions not discourage them, instead.

Answer: Indeed, the Energy-Related Inventions Program (ERIP) has made a number of significant achievements since it began. This program, like most others in the Conservation Program, must live within a more stringent budget. At the same time, ERIP is also experiencing a substantially reduced number of inventions submitted for evaluation.

QUESTION FROM SENATOR DOMENICI

RENEWABLE ENERGY

Question 1: With the tax credit, residential solar system did not become a common household system in areas where solar systems are feasible. Without the tax credit, some say that the industry may collapse. It seems that more R&D is needed and more demonstration projects are also essential to collecting data and improving the efficiency of the system so that it can be competitive in the market. Why did the Administration decide to defer the three existing demonstration projects? I am particularly concerned about the S.W. residential demonstration project that I mentioned to you in the Energy and Water Appropriations Hearing. I hope that you will have an answer for me today.

Answer: The DOE submitted a deferral for the S.W. Residential Experiment Station in Las Cruces, New Mexico, and the S. E. Residential Experiment Station in Cape Canaveral, Florida, because their work in evaluation of photovoltaic grid-connected residences and research on cost-effective installation techniques has been successfully concluded. The third station, the N.E. Residential Experiment Station in Bedford, Massachusetts, was not funded in the FY 86 budget; therefore, it is not part of the deferral. All objectives planned for these stations have been met and industry has the technology base to develop such systems commercially if appropriate. Residential grid-connected photovoltaic systems, however, will not be economically feasible until the price of the main component - the photovoltaic collector module - is reduced from the present $6.00 per peak watt to approximately $1.00 per peak watt. Consequently, the photovoltaic program focus is on developing the technology that will improve module efficiency and assist industry to achieve the desired module

price goals. Accordingly, the Department proposed a deferral in order to focus resources on the highest scientific and technical priorities while providing for continuity and momentum within the program.

QUESTIONS FROM SENATOR DOMENICI

PHOTOVOLTAICS

Question 2: What is the PV's cost as cent/KWh today vs. 10 years ago?

Answer: Today's cost is in the range of 50¢/kWh to 75¢/kWh depending on the size, type and location of the systems. This compares to the range of $20.00 to $40.00/kWh ten years ago.

QUESTIONS FROM SENATOR DOMENICI

PHOTOVOLTAICS

Question 3: What is the projected cost and what is the acceptable cost?

Answer: While projections, by their nature, involve an element of uncertainty, given current assumptions regarding cost of capital, likelihood of successful R&D, cost of competing fuels, and other technical and economic factors, the cost of electricity from photovoltaics in the early 1990's is projected to be 6¢/kWh to 10¢/kWh in today's dollars. This would place photovoltaics into the competitive range with other peak electricity generating systems.

QUESTIONS FROM SENATOR DOMENICI

PHOTOVOLTAICS

Question 4: With 50% funding cut, how long a delay will it cause?

Answer: It is likely that the timing of PV's competitive viability as a major energy supply technology will be influenced more by the uncertainty in utility capacity requirements, the price trends for competing fuels, industry R&D investment levels, and other factors, than the level of federal budget support proposed for FY 1987. The FY 1987 request focuses on materials research, at levels consistent with prior years, which represents the area critical to making major advances in cost and performance.

QUESTIONS FROM SENATOR DOMENICI

SOLAR THERMAL

Question 5: What is the result of "Solar One" since it became operational in 1982?

Answer: Solar One completed its test and evaluation phase on August 1, 1984, and began its three-year power production phase at that time under the Cooperative Agreement between the Department of Energy and Southern California Edison and their associates. The Solar One is operating more efficiently with each year of the power production phase. In the first year of power production operation, a total of nearly 8000 Mw hrs were produced. The current production is running 50% higher than the previous year and on winter solstice, December 20, 1985, the power production for that day exceeded the goal established by 12%. Further operational improvements are anticipated in the third year of operation. The conclusion of the third year operations on August 1, 1987, will end the activities to be accomplished under the existing cooperative agreement between the Department of Energy and Southern California Edison.

QUESTIONS FROM SENATOR DOMENICI

SOLAR THERMAL

Question 6: Of the three advanced heat engines with almost no moving parts: free-piston Stirling engines, sodium heat engines, and thermo-electrochemical engines, how far down the line will the technical feasibility be determined?

Answer: A regenerative thermo-electrochemical conversion concept is under development. Each major component of the concept has been successfully tested under laboratory scale conditions. A complete closed-loop test of the total system is planned for FY 86/87 to prove the technical feasibility of the concept. Ford Motor Company developed a 200 watt sodium heat engine and demonstrated technical feasibility by achieving a 19 percent engine efficiency. Additional R&D is underway to develop and prove technical feasibility of a higher efficiency engine by substituting mercury for sodium. The technical feasibility of the free-piston Stirling engine has been demonstrated with small 3 KWe engines and a 25 KWe engine being tested by Mechanical Technology, Incorporated, under the NASA Program. Further development, taking at least 3 to 5 years, will be required to establish reliable solarized engines in the 25 to 50 KWe size and establish economic feasibility.

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QUESTIONS FROM SENATOR DOMENICI

BIOFUELS

Question 7: Biofuels currently supply approximately 4% of the U.S. energy supply. Is this small percentage a disappointment from the previous projection? What incentives can we offer to encourage the use and production of biofuels?

Answer: The Department expects the current annual biofuels energy production of approximately 2.7 quads to increase to around 4.6 quads by the year 2010. The Department is pleased with progress to date, and plans to continue an applied research and development program (R&D) for biofuels. The planned R&D program is expected to yield a number of technical biofuels options for future energy markets. Therefore, the Department does not recommend any additional incentives to encourage the use and production of biofuels.

QUESTIONS FROM SENATOR DOMENICI

BIOFUELS

Question 8: What projects of biochemical conversion of municipal solid waste are presently undertaken by DOE?

Answer: The following projects are presently being undertaken in the biochemical conversion of municipal solid waste:

Project Title

- o Biotreatment of Municipal Solid Waste Ash to Recover Heavy Metals
- o Basic Microbial Research
- o Conversion of Organic Acids to Liquid Fuels
- o High Solids Digestion
- o Gas Flux Through Landfill Covers
- o Effluent Dewatering
- o Improved Anaerobic Digestion for Wastewater Treatment
- o Photo-enhanced Stability Rates of Anaerobic Digestion
- o Characterization of Extracellular Hydrolytic Enzymes
- o Refuse Conversion to Methane
- o Proof-of-Concept of the Production of Methane from Municipal Solid Waste and Sewage Sludge

QUESTIONS FROM SENATOR DOMENICI

WIND ENERGY

Question 9: In your testimony, p.23, you stated that "13,000 wind turbines are presently operating with 1100MW installed capacity. What is the actual generation output from the wind turbines?

Answer: The large majority of these turbines are in wind farms in California and they produced 622 million kWh of energy during 1985. That is more than three times the energy produced by wind turbines in the state during 1984 and 13 times 1983 production. The increase is attributed to the new capacity installed during 1985 and to the improved performance and reliability from newer and upgraded older machines.

QUESTIONS FROM SENATOR DOMENICI

WIND ENERGY

Question 10: On the Mod-5 Wind turbine project (Boeing), DOE redirected some funds last year and then deferred the funding. What is the rationale for the decisions?

Answer: The FY 1985 Supplemental Appropriations legislation provided an additional $2.5 million for Mod-5 from existing Solar Program funds. These funds were redirected from the Sacramento Municipal Utility District (SMUD) photovoltaic program, which SMUD elected to discontinue, and were obligated to Mod-5. In FY 1986, funds were requested by DOE to close out the Mod-5 project. In light of the difficult national budget situation and the declining interest in very large, multi-megawatt wind turbines by industry and utilities, it is believed that the Mod-5 is not as high a priority as other wind R&D work. In view of the ordering of priorities, deferral of the additional appropriated FY 1986 Mod-5 funding is considered prudent.

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QUESTIONS FROM SENATOR DOMENICI

ENERGY STORAGE

Question 11: What are the funding requests for fuel cells R&D in Energy Storage and in Transportation?

Answer: In the area of fuel cells, $400,000 has been requested in the FY 1987 budget for Energy Storage for continued work to investigate higher efficiency fuel cells for applications in the transportation sector. In addition, in the area of electrocatalysis, $630,000 has been requested to help develop an atomic-level understanding of complex electrochemical reactions of electrode surfaces and to find effective catalysts for oxygen reduction and generation in alkaline and acid electrolytes. These are key research needs in order to develop a higher efficiency fuel cell.

In the transportation area under the Interior appropriation, no funds have been requested in FY 1987 for fuel cells research.

QUESTIONS FROM SENATOR DOMENICI

ENERGY STORAGE

Question 12: The Congress appropriated, for FY 1986, an additional $2 million for expanded effort in electrochemical research, specifically for fuel cells. Why does DOE purposely ignore Congress's directive and not pass through the funding to the program?

Answer. The Department has reviewed FY 1986 appropriated funds, as well as FY 1987 funding requirements, in light of the need to reduce Federal spending wherever possible while focussing research expenditures in areas of highest technological priority. The Department has proposed deferrals in some areas, including the proposed expansion of effort in electrochemical research, in lieu of new budget authority for FY 1987. The proposed deferral will allow for a continuity of effort in highest priority research, including electrochemistry relevant to fuel cells, while contributing to reduced Federal spending. Under the Department's current proposals for FY 1986 and FY 1987, significant research will take place in electrochemistry and electrocatalysis, as well as more applied research relating to a specific fuel cell concept relating to potential application of transportation needs.

QUESTIONS FROM SENATOR MCCLURE

CONSERVATION

Question 1: Most industries rely on unit operations often based on energy inefficient and costly phase changes. Most process improvements are evolutionary in nature. Is DOE giving any attention to the start of a major research effort on development of revolutionary energy efficient, cost effective methods for processing raw and intermediate materials?

a. If the answer to question #1, is yes, please describe effort.

Answer: DOE supports development of "revolutionary" industrial methods. Examples of current projects in this category, and organizations conducting the research, are:

- o Carbothermic reduction of alumina - Massachusetts Institute of Technology.
- o Thin section casting of steel (two projects) - U.S. Steel/Bethlehem and Westinghouse/Armco.
- o Dry coating of textiles - Georgia Institute of Technology.
- o Molten salt separation of oxygen from air - Air Products and Chemicals, Inc.
- o Impulse drying of paper - Institute of Paper Chemistry.
- o Gasification of paper industry black liquor - Champion Paper Company/Rockwell.

- o Caustic concentration by membrane fuel cells - Physical Sciences, Inc.
- o Membrane separation of organic liquids - State University of N.Y.
- o Food industry membrane separation processes - Bend Research.
- o Hydrate freeze concentration of sugar solutions - Heist Engineering.

Another area of DOE activity aimed at major changes involves industrial waste materials that normally are land filled. However, the application of novel technology can turn those wastes into useful products. Examples of projects in this area are:

- o Textile wastes for molding products - North Carolina State University.
- o Conversion of cheese whey to ethanol - Purdue University.
- o Methane production from pharmaceutical wastes - Hydroqual/Merck.
- o Utilization of roofing wastes - Manville.
- o Auto shredder residue as fuel - Energroup.

QUESTIONS FROM SENATOR MCCLURE

CONSERVATION

Question 2: Last year, the Department was directed to use available funds to complete those steps necessary to release and distribute the film, "The Energy Integrated Farms Systems Irrigation." Please provide the committee with details of the steps of that have been taken to date, the current status of this film and the projected date when the film will be released.

Answer: We assume the film to which the Senate Interior Appropriations Subcommittee report refers is "The American Farm: Water and Energy Planning in Agriculture." This film was completed in 1982. While its information on irrigation is now somewhat outdated, we are currently determining whether release in movie or videotape form would be more cost-effective. We expect to make copies available to the U.S. Department of Agriculture for distribution through their extension service by July 1, 1986.

QUESTIONS FROM SENATOR ROCKEFELLER

HIGH TEMPERATURE MATERIALS AND CERAMICS RESEARCH

Question 1: Madam Secretary, in your testimony (both written and oral) you mention research being done on high temperature and ceramic technology. I believe this is a very important research endeavor to be pursuing and is very important to the competitive abilities of American industry in years to come. Please describe your current program in this regard, the specific industry involvement and the past and future budget requirements?

Answer: The total funding for structural ceramics R&D throughout the FY 1987 DOE budget amounts to approximately $19 million. There is additional work supported within DOE which is focused on ceramics research for unrelated applications such as nuclear power and electronics, and although this support may be substantial, it does not have application to structural ceramics requirements.

Within the Office of Conservation and Renewable Energy, the major activities concerned with high temperature materials and ceramics research are being carried out in the Transportation program, with emphasis on applications in advanced heat engines. These activities include basic ceramics technology research as well as engine related component development. In addition, a user oriented High Temperature Materials Laboratory (HTML) is under construction at the Oak Ridge National Laboratory (ORNL), which will make available to industry and universities equipment,

instrumentation, and scientific staffs necessary for advanced high temperature materials R&D.

Industry has a great and continuing involvement in our ceramics and high temperature materials research. The planning for our research agendas is accomplished through comprehensive industry assessments of requirements. Industry is directly involved in the implementation of our research activities through competitive, cost-shared contractual arrangements. In addition, industry is involved in oversight and guidance for our work through periodic workshops, membership on the National Materials Advisory Board Committee which reviews the program, and membership on the HTML Advisory Committee which reviews the construction and operations of the HTML. In FY 1986 approximately $15 million in funding for ceramics related R&D was distributed to over 25 U.S. ceramics and engine companies encompassing all of the major ceramics producers and manufacturers in the country.

The funding provided by DOE for structural ceramics R&D in FY 1985, FY 1986 and FY 1987 is listed below:

Conservation		Funding ($ in Millions) FY 1985	FY 1986	FY 1987
Transportation		17.9	18.7	11.7
Industry		1.7	1.5	.8
Energy Utilization Research		1.8	1.8	1.0
Fossil Energy		1.5	1.8	1.5
Energy Research		4.6	4.5	4.5
	TOTAL	27.5	28.3	19.5

QUESTION FROM SENATOR FORD

PHOTOVOLTAICS

Question 1: Last year your budget request for photovoltaics was $43.6 million for operating expenses and $1.2 million for capital equipment.

You said last year, "This FY 1986 program proposes to aggressively undertake critical research efforts toward developing advanced technologies that show great promise."

This year you request $19.6 million for photovoltaics and $1.0 million for capital expenses. That's a 54% decrease from last year's request. Have we beaten the Japanese in this area? Have we run out of promising areas of research? Is this research no longer important?

Answer: The Japanese (and other foreign photovoltaic programs) emphasize certain options and in those areas they will continue to provide significant competition to U.S. efforts. By concentrating on materials research, the U. S. Government program, together with increasing industry R&D investment, will still include a broad range of research on a number of important and promising options, some of which are unique to the U. S. This strategy is expected to provide continued significant progress while being cognizant of fiscal needs.

QUESTIONS FROM SENATOR FORD

PRESIDENT'S PROPOSED BUDGET FOR FY 1987

Question 2: Who is going to monitor the State's expenditure of the Exxon oil overcharge money? Aren't you the logical ones? Certainly the Court doesn't have the manpower. Do you request anything in your budget for that? Wouldn't you want to know what the States are doing since 4 out of the 5 programs relate to energy conservation?

Answer: Pursuant to the Court order, the Department has required the States to certify that they will use the Exxon funds as prescribed in the Court order before receiving their allocation. Having done so, they would be expected to assure that the order is being followed. The Court order also requires that the States annually submit a report to the Department and the Court describing their use of the funds. This will provide information of value regarding the States' expenditures resulting in sufficient information as to the use of the funds. The Department will serve the States in an advisory role to assist in appropriate uses of the funds.

QUESTIONS FROM SENATOR FORD

RESEARCH ON OIL HEATING EFFICIENCY

Question 3: Almost 20% of U.S. homes heat with oil. Oil use may well increase with prices declining. How much money is in your budget for research on improving the combustion efficiency of oil burning for heating?

Answer: Applied research on improving the combustion efficiency of oil burning for heating buildings has been funded by the Department for several years under Technology and Consumer Products. Much of the applied research on this topic has been accomplished and the results are ready for further development and commercialization by the private sector. For example, this research has paved the way for efficiency improvements of at least 25% compared to conventional oil-fired technology. Consequently, we have not requested further funding for this particular activity. However, we will continue to fund research on thermally activated heat pump technology which could be applicable to oil-fired systems.

Basic research on the liquid fuel combustion process is being funded by the Department under the Multi-Sector line item. Approximately $900K is being spent on this work in FY 1986 and $600K was requested for FY 1987.

QUESTIONS FROM SENATOR FORD

GAS MILEAGE GUIDE

Question 4: Why aren't you requesting funding for publication and distribution of the Gas Mileage Guide? Have you ever seen a newspaper article that printed all the information that's contained in your guide? Don't they usually summarize it? What does it cost to print this? You say yourself that transportation is 61% of the U.S. petroleum consumption, how can you justify not ensuring that detailed information is out there?

Answer: We believe that the fuel economy information contained in the Gas Mileage Guide is already available to the public without the actual publication and distribution of the Guide by DOE. The detailed fuel economy figures, including comparisons, are already displayed on the window stickers of individual new cars and light trucks. In addition, the Environmental Protection Agency (EPA) makes available to the press all of the new vehicle fuel economy estimates at the beginning of each model year. Although most newspapers have in the past published only limited information on new car fuel economy, concentrating on the "best" and "worst" models, publications such as the automotive trade publication Automotive News have included new car fuel economy for all new cars and light trucks. Other publications, such as Consumer Reports, have also provided detailed information on new car fuel economy.

To produce and distribute approximately three million copies of the model year 1988 Gas Mileage Guide, and to provide for secondary distribution and a mid-year addendum, would require $700,000 in FY 1987.

QUESTIONS FROM SENATOR BUMPERS

GAS HEAT PUMP RESEARCH

Question 1: What funding level has DOE requested for gas heat pump research and development in 1987? Will the development of a gas heat pump for market introduction by 1990 be feasible at this funding level? By what year?

Answer: The Department of Energy has requested $4.0 million for thermally activated heat pumps in FY 1987. This consists essentially of research on gas-fired systems, but the basic technology could be extended to oil also. If this work is successful, the Department believes that the technology could be ready technically for commercial market introduction in the early 1990's. However, actual market introduction will depend upon a number of factors, including future energy prices and the costs of mass-produced heat pumps. Some analysts believe that market introduction will begin for specialized commercial applications followed by the high-volume residential market in the mid-1990's.

QUESTIONS FROM SENATOR BUMPERS

GAS HEAT PUMPS MARKET INTRODUCTION

Question 2: Is the funding profile recommended by GRI in its testimony before the Committee reasonable for the accomplishment of market introduction by 1990?

Answer: The Gas Research Institute (GRI) has recommended a budget of $10 million in gas heat pumps as part of a cooperative program with GRI. This represents an increase of $6 million over the DOE request. GRI believes that market introduction by 1990 might be possible. However, it must be recognized that timing of market introduction is subject to a number of uncertainties, not the least of which is the 1990 price of energy.

QUESTIONS FROM SENATOR BUMPERS

HEAT PUMPS - FOREIGN RESEARCH AND DEVELOPMENT

Question 3: What is the status of foreign R&D on heat pumps? When is it likely that heat pumps manufactured in Japan or other nations will reach American markets?

Answer: Heat pumps and air conditioners of the electrically driven type are on the market in Japan. Only a few of these are now available in the U.S. There are, however, successful efforts now being made to market Japanese heat pump components, such as compressors, in the United States. Marketing of complete systems is expected to follow once Japanese domestic markets are saturated.

In the case of gas heat pumps, there are substantial research and development efforts underway in several foreign countries, principally Japan, Germany, France, and the Netherlands. The Japanese program appears to be the most advanced towards producing a marketable product since large scale field tests are now being conducted in Japan on residential internal combustion engine driven heat pumps.

Under U.S. gas industry sponsorship a number of these units will be field tested in the U.S. later this year. Japanese gas heat pump technology may be exported and commercialized in the U.S. in the early 1990s.

Department of Energy
Washington, DC 20585

April 16, 1986

Honorable Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On March 17, 1986, Donald L. Bauer, Acting Assistant Secretary for Fossil Energy, appeared before the Energy and Natural Resources Subcommittee on Energy Research and Development to discuss the FY 1987 budget authorization request for fossil energy.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Mike Gilmore or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

QUESTIONS AND ANSWERS

Relating to the

MARCH 17, 1986, HEARING

Before the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
of the
COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

WITNESS: DONALD L. BAUER
ACTING ASSISTANT SECRETARY FOR FOSSIL ENERGY

QUESTIONS FROM SENATOR JAMES A. McCLURE

CLEAN COAL TECHNOLOGY

Question 1: Congress has shown considerable interest in the development of evolutionary clean coal technology. What major efforts are currently being pursued by the Department of Energy to develop new and revolutionary concepts for clean coal technology?

a: Describe the work going on in each of the following areas: 1) liquefaction, 2) gasification, 3) magnetic separation, 4) supercritical extraction, 5) laser-stimulated processes, and 6) other novel processes.

Answer: In the Advanced Research program under Coal Liquefaction, several projects are underway to investigate the use of microorganisms for biological liquefaction of coal and to explore novel catalytic materials for upgrading of coal derived syncrudes. Both of these efforts are aimed toward eventual development of new and revolutionary technology that will operate at much lower temperatures and/or pressures than those employed in current liquefaction processes.

Surface Coal Gasification technology combined with novel processes for the removal of sulfur, particulates trace elements, etc., at elevated temperatures offers significant potential as an economically attractive energy supply option to the utility and industrial sectors. Accordingly, the Surface Coal Gasification program in combination with the Gas Stream Cleanup program is supporting a wide range of projects that show considerable promise as new and revolutionary concepts. Included among these concepts are:

- Sulfur Removal from High Temperature Gas Streams

  Some of the concepts being explored include the use of zinc ferrite systems, mixed-metal oxides and unsupported mixed metals in the form of solid solutions. The most advanced of these concepts is the zinc ferrite technology which is at the Process Development Unit scale of testing.

- Particulate Removal from Gases at Elevated Temperatures and Pressures

  A number of devices are being tested and/or developed that show promise for removing particles from hot gas streams at efficiences and size distributions that will permit the cleaned gas to be used as feed to a combustion turbine. This device research involves such concepts as high temperature, high pressure electrostatic precipitative granular bed filters; ceramic fabrics; low turbulence, high efficiency cyclone separators; ceramic cross flow filters; and acoustic agglomeration.

- In-Bed Sulfur Capture

  Under study is a promising concept involving capturing the sulfur in the coal during the process of gasification before it leaves the gasifier. In this approach the "sulfur getter" is added to the gasifier along with the coal and the sulfur "captured" is discharged along with the ash.

e Novel Methods of Removing Acid Gases (H_2S and CO_2) at Low Temperatures

The National Bureau of Standards is working on a process to remove acid gas from synthesis gas using ion-exchange membranes. The approach is to use liquid as a membrane material and to incorporate in the liquid a carrier which will react with the acid gas forming a complex which diffuses through the membrane. The acid gas is then separated from the carrier and swept away. The process is promising as a method of overcoming the difficulties of using immobolized liquid membranes, namely the loss of solvent due to fouling and condensation where the solvent is forced through the membrane by a pressure gradient. The ion-exchange membrane has an advantage in that the carrier is retained in the membrane by strong electrostatic forces.

In magnetic separation a project is being conducted to investigate the feasibility of electrostatic enhancement of magnetic separation of ash and pyritic sulfur from coal.

Research on supercritical extraction of coal has not led to encouraging results. The only work currently being pursued is included in three small university projects involving supercritical desulfurization with alcohols; supercritical

steam extraction of coal; and a combined hydropyrolysis-supercritical extraction with water and/or methyl alcohol.

No major efforts are currently in progress that involve laser-stimulated processes.

With regard to other novel processes, a revolutionary concept for clean coal technology being pursued by DOE is the microbial removal of organic sulfur from coal. As a result of a Program Research and Development Announcement in FY 1985, two contracts were awarded for work in this area. One was awarded to Atlantic Research Corporation to develop a microorganism capable of removing 90% organic sulfur from various coals and the other to the Institute of Gas Technology to develop microorganisms for removal of organic sulfur from coal and to determine the effects of process conditions on efficiencies and rates of organic sulfur removal.

QUESTIONS FROM SENATOR JAMES A. McCLURE

CLEAN COAL TECHNOLOGY

Question 2: The quality of fossil (coal) resources vary considerably across the country. The variations in quality present use problems such as systems fouling, pollution, and disposable wastes. What efforts are currently being made to foster regional collaboration between laboratories, universities and industry to solve these problems?

Answer: The DOE's Office of Fossil Energy is addressing the regional characteristics of coal in several research areas, including: 1) removing sulfur, mineral matter and ash from coal before it is used, during the combustion process, and from waste products, 2) the study of coal structure and how it relates to process reactivity, and 3) understanding how parameters such as coal particle size and structure affect combustion rates and efficiency.

Numerous other DOE studies of the removal of pollutants (e.g., sulfur, mineral matter and ash) are underway, as are studies of coal combustion kinetics and the effect of parameters such as particle size, temperature, and prior history upon them. Coals vary significantly from region to region, in particular in rank, moisture, sulfur, and mineral matter content. These are all key characteristics that must be considered in determining whether certain coals can be put to certain specific uses, and each of the research teams in the program investigates such characteristics using a variety of coals from several regions.

The work is undertaken at industrial laboratories in the east and west (e.g., TRW, United Technologies Research Center, Energy

and Environmental Research, Inc., Advanced Process, Inc.), at several national laboratories (e.g., Ames, Argonne, Sandia and the Idaho National Engineering Research Laboratory), and at many universities (e.g., Massachusetts Institute of Technology, Lehigh University, Pennsylvania State University, Ohio State University, Southern Illinois University, Louisiana State University, University of North Dakota, Colorado School of Mines, Brigham Young University, University of Arizona, California Institute of Technology).

DOE has cooperative agreements with Southern Illinois University (SIU) to conduct research on high sulfur coal in the areas of coal science, coal preparation, coal conversion and coal utilizaton; and with the University of North Dakota Energy Reseach Center (UNDERC) to conduct research on low rank coals including such areas as coal preparation, waste management, fluidized bed combustion, flue gas cleanup and coal water slurries.

Even though DOE's coal characteristics research is conducted at a number of industrial laboratories, universities and national laboratories throughout the country, collaboration among all these sectors is maintained. For example, in the Advanced Research and Technology Development (AR&TD) program, a research team consisting of four industrial laboratories, eight universities and a national laboratory is coordinated by a steering committee composed of representatives of all participating institutions. Thus regional interests and the

parameters affected by the regional variations in coal are taken into account in both the design and in the execution of the study. In the Coal Preparation program, a cooperative agreement is maintained with the electric utilities' research arm -- the Electric Power Research Institute (EPRI) — to test physical coal cleaning technology.

In summary, the program is integrated in two directions — across the industry, university, national laboratory sectors, and across the regional characteristics and differences among coals.

QUESTIONS FROM SENATOR JAMES A. McCLURE

CLEAN COAL TECHNOLOGY

Question 2a: What work is presently going on or being planned in DOE in the following areas: 1) removing sulfur ash and heavy metal from coal, 2) relating coal structure to process reactivity, and 3) understanding coal particle size and structure to combustion rates and efficiency. Describe program location and the level of effort of each of the above.

Answer: With regard to removal of sulfur, ash and heavy metals from coal, surface coal gasification, in itself, is a process that separates the sulfur and ash from coal and concentrates them as required for treatment and disposal. In that regard, all R&D that advances the state-of-the-art of coal gasification is directed towards the development of processes for the removal and control of ash and heavy metals from coal. Some of the major activities in this area are in progress at the Waltz Mill agglomerating ash, fluidized bed PDU gasifier; METC; the General Electric PDU gasifier; KILnGAS, etc., and constitute a level of effort approaching $25 million in FY 1986 of which $1.9 million has been deferred and $3.8 million proposed for rescission.

The Coal Preparation Program is also directed towards removing sulfur and mineral matter from coal. Major activities include testing microbubble and electrostatic devices at the EPRI's Homer City Test Facility. Other advanced physical and chemical coal cleaning systems are being developed at PETC and numerous other locations. The level of effort in FY 1986 is

approximately $13 million of which $2.6 million has been deferred.

With regard to relating coal structure to process reactivity, there are a number of projects in place at the National Laboratories, METC, universities and in the industrial sector on this topic. Such projects as the following are examples of this effort.

- Ash and slag characterization (UNDERC)
- Kinetics of high temperature and pressure char-steam reaction in coal gasification (West Virginia University)
- Reaction kinetics and mechanisms of ash agglomeration - Institute of Gas Technology (IGT)
- Catalytic gasification of graphite (Lawrence Berkeley Lab)
- Wet carbonization of lump size, low rank coals by a non-slurry approach (IGT)
- Gasification with semi-volatile catalysts (IGT)
- Depolymerization and cross linking reactions in liquefaction (Advanced Fuel Research)

- Reactivity of coal in direct hydrogenation processes (Colorado School of Mines)

- Prediction and measurement of operating parameters for entrained flow coal gasification processes (BYU)

- Modeling of slow heating reactors (USP)

Each of these projects is fundamental in nature and is, in general, funded for multiple years at levels ranging from $75,000 to $450,000 per year.

With regard to research on the relation of coal particle size and structure to combustion rates and reactivity, a university-industry-national laboratory team is studying combustion kinetics and efficiency of pulverized coal combustion (including effects of particle size and coal composition). This team is composed of two industrial laboratories (TRW and United Technologies Research Center), six universities (Massachusetts Institute of Technology, Ohio State University, Pennsylvania State University, California Institute of Technology, Princeton, University of North Dakota) and a national laboratory (Sandia); FY 1986 funding is about $1,900,000.

QUESTIONS FROM SENATOR PETE V. DOMENICI

DEFERRALS

Question 1: DOE will derive 55% of its FY 1987 budget from deferrals of money from their FY 1986 appropriations. Some of the deferrals represent a significant portion of the FY 1986 budget authority. For example:

a) $13M (or almost half) of the $28M for Magnetohydrodynamics is deferred
b) $22M (or 65%) of the $34M for fuel cells is deferred
c) $8M (or 20%) of the $41M for surface coal gasification is deferred
d) $6M (or 20%) of the $32M for coal liquefaction is deferred, and
e) $5M (or 15%) of the $32M for control technology and coal preparation is deferred

It is probably not just a "coincidence" that these programs that are targeted for the deferrals are the very same programs that Congress boosted significantly from the meager and sometimes nonexistent FY 1986 DOE budget request. By these deferrals, the Department is ignoring the intent of Congress. Does this mean that we will be ignored again in FY 1987 if we chose to boost some program areas above what DOE has requested? Could this mean that the Clean Coal program, which never was supported by DOE in the first place, might be gutted by this deferral process?

Answer: In the formulation of the Fossil Energy budget, the Department performs a careful analysis of how projects proposed for funding fit into DOE's mission. During the budget process, the Department establishes priorities for programs within the constraints of total funds available. When funds are added by Congress to our budget, a reconsideration of the delicate balancing of funding high priority R&D programs and achieving deficit reduction must necessarily be undertaken.

Through the deferral and rescission process as established by Public Law 93-344, Title X of the Congressional Budget and Impoundment Control Act of 1974, Congress has provided the

Executive branch with a mechanism that allows such reconsideration, followed by presentation to the Congress of our reasoned recommendations.

Funds that are Congressionally added to our budget are always reviewed carefully. Depending on critical programmatic priorities and needs and budgetary constraints, these additional funds are used to implement the indicated programs or the appropriate deferral or rescission recommendations, with justifications therefor are transmitted to Congress.

Specifically, the Administration has gone on record on recent occasions as supporting the Clean Coal Technology Program. Currently, there are no plans to defer funding for the Program. A Program Opportunity Notice soliciting competitive proposals for funding under this program is currently "on the street".

QUESTIONS FROM SENATOR PETE V. DOMENICI

FOSSIL ENERGY R&D BUDGET

Question 2: What was DOE's original budget request to OMB in the fossil energy program area? What was OMB's passback? Which of the fossil programs did DOE then appeal? What was the result of these appeals?

Answer: The OMB budget request for Fossil Energy R&D was $272,521,000.

The OMB allowance of $150,090,000 provided $90,090,000 (including program direction funds) for activities that can be considered technology base and which are primarily performed at universities, Energy Technology Centers and national labs, and $60,000,000 for three aggregated Cooperative R&D Venture Pools intended to represent work performed by industry. Fossil Energy did not appeal the dollar amount of the OMB allowance. However, we did request that the OMB allowance for the Cooperative R&D Venture Pool be modified to the status and size of a pilot program.

DOE's recommendation concerning the redistribution of the OMB allowance was agreed to by OMB, and the Cooperative R&D Venture Pool was limited to $12,500,000. The remaining $137,590,000 was allocated to technology base activities.

QUESTIONS FROM SENATOR PETE V. DOMENICI

COOPERATIVE R&D VENTURES POOL

Question 3: When will decisions be made as to the specific programs that will be funded from the $12.5M targeted for Cooperative R&D Ventures Pool?

Answer: The decision has been made that the Cooperative R&D Ventures Pool, proposed for FY 1987, will focus on the extraction programs in the Department's Office of Fossil Energy. This specifically includes the Underground Coal Gasification program, the Oil Shale program, the Enhanced Oil Recovery program, and the Unconventional Gas Recovery program. The joint venture concept is intended to give the private sector greater flexibility, commensurate with their increased financial responsibility, in proposing specific programs, projects, and technologies, and in the establishment of U.S. resource development strategies and project priorities.

The actions anticipated (in order) in establishing and pursuing the Joint Ventures program include:

- Preparation of a planning document discussing the details of the cooperative ventures format, its operation and contents, and the procedures that will be used by DOE to develop such a venture.
- Holding of a public meeting, properly noticed, involving industry and other interested parties, which will provide the forum for input into the system as to how the program and its

procedures should be structured in order to generate the greatest likelihood of project success.

- Issuance of a final document formally inviting industry to propose venture participation with the U.S. DOE.

The final mix of projects selected will be determined by a free and open competition. Accordingly, no opinions can be offered at this time regarding the extraction technologies that may ultimately be chosen for venture pool participation.

QUESTIONS FROM SENATOR PETE V. DOMENICI

COOPERATIVE R&D VENTURES POOL

Question 4: I noticed that your FY 1987 budget request for underground coal gasification is zeroed. Yet one of the areas you intend to fund via the $12.5M joint venture money will be underground coal gasification.

The program you zeroed was already, in fact, a joint venture project between Lawrence Livermore, the Gas Research Institute, plus several other private organizations. This project, involving a large-scale test in Hanna, Wyoming, is currently being planned for completion in late FY 1987, and is funded approximately 60% by the private participants. GRI had recommended DOE funding of $5M in FY 1987. Without a commitment from DOE for FY 1987 funds, further negotiations on the project will be stalled.

- Does DOE intend to continue its commitment to the Wyoming project by utilizing a portion of the $12.5M Joint Venture Pool?
- If so, how much money can be committed to the project?
- I understand that the test cannot be done without minimal support from DOE of at least $3.25M. Will DOE be able to provide at least this much funding for the project?

Answer: The proposal for this project, to be undertaken by GRI in concert with an industrial consortium, has been under active consideration and negotiation since FY 1985. Funding was appropriated in both FY 1985 and FY 1986 for the effort. Problems were encountered with the initial site selected by the consortium and a hiatus occurred as an alternate site (Hanna, Wyoming) was identified and an attendant agreement was consummated to incorporate the new landholder into the consortium.

As you note, the project is over 50 percent co-funded by an industrial consortium. The DOE funds for the project (which will take place in late FY 1987) were appropriated in FY 1985

and FY 1986 and are now included in funds available for the Underground Coal Gasification program. While some future program modifications may be required, funds are anticipated to be sufficient to conduct a viable project, and no FY 1987 funding will be required, particularly in view of the fact that industry also has shown some willingness to share a larger portion of the burden of funding in selected areas.

It is anticipated that at least $3.25 million will be applied to this project in part through direct funding to the consortium and the balance of DOE investment will take the form of services provided in support by the Lawrence Livermore National Laboratories and the Western Research Institute.

QUESTIONS FROM SENATOR PETE V. DOMENICI

COOPERATIVE R&D VENTURES POOL

Question 5: In the Cooperative R&D Ventures Pool, one criteria for project selection will be the assurance that federal funds will not be displacing private sector funds. How is this assurance to be determined?

Answer: One of the objectives of the proposed Ventures Program is to indeed avoid the displacement of private sector funds. With the drop in oil prices, oil companies have fewer resources to apply to R&D on advanced extraction technologies. Consequently, it is expected that they will be more willing to pool what resources they do have to address key research needs through a Cooperative R&D Venture which will provide a mechanism for formation of industry research consortia and resource pooling with reduced anti-trust implications. As with any R&D funding strategies, there can be no assurance or guarantee that some private sector funds will not be displaced. However, we expect that profit motives and other business ambitions will provide incentives for the business sector to contribute only the maximum share they view as "affordable", given earning potential in other investment areas. Therefore, Federal displacement of private funds should be minimized.

QUESTIONS FROM SENATOR PETE V. DOMENICI

CLEAN COAL TECHNOLOGY PROGRAM

Question 6: FY 1986 funding for Clean Coal Technologies was $99M. How is this money being spent?

Answer: DOE intends to use the $99.4 million appropriated for the Clean Coal Technology program in FY 1986 for a portion of the cooperative agreement awards resulting from the competitive solicitation, administrative costs and an overrun reserve. A small portion of the overall program appropriations (FY 1986 - FY 1988) have been reserved as required by the Small Business Innovation Research Program Act.

QUESTIONS FROM SENATOR PETE V. DOMENICI

CLEAN COAL TECHNOLOGY PROGRAM

Question 7m: Holding back 25% of the Clean Coal Technology to cover cost overruns and DOE costs seems like an awfully large reserve. Does DOE plan to hold back 25% of the $12.5M Cooperative Ventures money for a similar reason?

Answer: Of the $397.6 million for Clean Coal Technology, $25 million will be held in reserve for overruns; $4.9 million will be set aside for SBIR, and $5.5 million will be used for administrative and contracting costs for the program. All of this comes to less than 10% of the $397.6 million appropriated for the program.

Since the $12.5 million Cooperative Ventures program is still in the planning process, no decision has been made at the time on whether to have a specific set-aside for cost overruns.

QUESTIONS FROM SENATOR PETE V. DOMENICI

COOPERATIVE PROGRAMS

Question 7b: What other cooperative programs in DOE (fossil or otherwise) have a similar reserve? What are the percentages of funds that are reserved in these programs?

Answer: The Department of Energy has no other cooperative programs which have similar reserve clauses such as those noted for the Clean Coal Technology program. However, it should be noted that the Department's other cooperative R&D programs are substantially different in character from the Clean Coal Program. For example, the Clean Coal Program is the only major demonstration activity within Fossil Energy. Also, the Congress provided specific guidance in the Clean Coal Program to allow funding of cost overruns of up to 25%. No such Congressional guidance exists in other Fossil Energy R&D programs.

In the past, the Department, through Public Laws 96-126 and 96-369 on alternate fuels production, was required to establish default reserves for loan guarantees. These are the only instances where reserves of this type were established and they were specified in the public laws.

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QUESTIONS FROM SENATOR PETE V. DOMENICI

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 8: What percentages of the total program costs does DOE contribute to the joint DOE/EPRI "advanced coal cleaning development and test program?"

Answer: The DOE/EPRI project agreement does not specify a fixed cost share percentage. The agreement states that EPRI will provide the one time capital cost for equipment and equipment modification at the CCTF, the recurring costs for real property, e.g., coal purchases, and the annual expenses for operation of the facility (labor, overhead, maintenance and power requirements). DOE will provide those costs associated with the design, construction and installation of the most promising concepts at the CCTF. Through FY 1986, the DOE contribution has been approximately 72 percent of the total program costs.

QUESTIONS FROM SENATOR PETE V. DOMENICI

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 9: Does DOE have any plans to do field testing of its program for microbial removal of organic sulfur from coal? Is there interest from the mining community to jointly fund such a test?

Answer: Research on microbial methods for removing organic sulfur from coal is currently being carried out at laboratory scale. With successful completion at this scale, testing at a further level of scaleup is planned for FY 1987. As the feasibility of this approach is established, we would anticipate increased coal industry interest and cost sharing.

QUESTIONS FROM SENATOR PETE V. DOMENICI

FOSSIL ENERGY R&D

Question 10: What is the ratio of fossil energy funds directed to DOE labs vs. Energy Technology Centers vs. universities for FY 1986? What ratio is anticipated for FY 1987?

Answer: The folowing represents the percentage of total available operating expense funds (BA) directed to DOE National Laboratories, Energy Technology Centers and Universities for FY 1986 and FY 1987.

($ in thousands)

	FY 1986 B/A OPEX	FY 1986 PERCENT	FY 1987 B/A OPEX	FY 1987 PERCENT
National Labs	31,570	9.4%	12,089	8.8%
Universities	31,860	9.4%	9,100	6.6%
METC and PETC	59,954	17.8%	52,254	38.0%
	123,384	36.6%	73,443	53.4%
B/A OPEX Total	336,787	100.0%	137,590[1/]	100.0%

1/ Does not include $12,500,000 for the Cooperative R&D Ventures Pool.

QUESTIONS FROM SENATOR PETE V. DOMENICI

FOSSIL ENERGY R&D

Question 11: The 64% cut in Coal Liquefaction, 58% cut in Fuel Cells, 28% cut in Heat Engines, 83% cut in Surface Coal Gasification, the complete phase-out of MHD and underground coal gasification, 60 to 70% cuts in all Petroleum Research areas, and 38% cut in Unconventional Gas Recovery tells me that a lot of the research programs now underway will have to be terminated prematurely. Could the Department provide the Committee with a completE list of all programs in fossil energy that will be terminated in FY 1987 and the cost of termination for each program?

Answer: The list of major activities not continued into FY 1987 is as follows:

- o Coal Liquefaction
  - Wilsonville two-stage liquefaction pilot plant
  - LaPorte liquid phase methanol PDU
- o Surface Coal Gasification
  - Waltz Mill fluidized bed gasifier
  - KILnGAS coal gasification system
- o Fuel Cells
  - Phosphoric Acid fuel cells
- o Combustion Systems
  - TVA's 160 MWe Atmospheric Fluidized BED (AFB) demonstration project

- o Underground Coal Gasification
  - Follow-on research and development activities will be pursued through the Cooperative R&D Ventures Pool.

- o Magnetohydrodynamics
  - The termination of the MHD program includes ending operations of the Coal Fired Flow Facility (CFFF) in Tennessee and the Component Development and Integration Facility (CDIF) in Montana.

The termination costs for these projects are associated with the close out of ongoing multi-year contracts and in most cases these contracts expire in accordance with their terms (the projects having been completed) without any cost to the Government. The following are estimated termination costs for the other projects not carried into FY 1987.

1.	Magnetohydrodynamics (various contracts)	$4.0 million
2.	Wilsonville (Southern Company Services)	1.5 million
3.	Waltz Mill (KRW)	1.0 million
4.	LaPorte Pilot Plant	.4 million

QUESTIONS FROM SENATOR PETE V. DOMENICI

GREAT PLAINS

Question 12: What is the status of the Great Plains project? When will DOE's commitment to the management and monitoring of this project end?

Answer: Plant Operations

The Department continues to operate the plant, addressing the efficiency of operations and the capital construction projects deemed necessary for environmental or economic reasons. SNG production for the past six months are tabulated below.

SNG Delivered	Average MMSCF/DAY	Percent Capacity
August 1985	118.6	86.3
September	125.3	91.1
October	140.9	102.5
November	135.4	98.5
December	119.1	86.6
January 1986	136.3	99.1
Average Aug. 85-Jan. 86	129.3	94.0

The CY 1986 operating budget for the plant has been reviewed and approved by the Department. A capital budget of $7.1 million for CY 1986 has also been approved. Of the $7.1 million, $2.0 million is for the completion of the four remaining odor projects necessary to bring the plant into compliance with North Dakota odor standards, $3.0 million is for projects directed at reducing sulfur emissions, and the remaining $2.1 million is for projects necessary to maintain or improve upon current production levels.

Litigation

On January 14, 1986, the North Dakota Court found:

- That state law is not applicable and that plaintiffs (DOE/DOJ) are entitled to a summary judgment for foreclosure.
- The defendant pipeline companies are liable to the plaintiffs (DOE/DOJ) for the difference between the contract price and the market value price and granted the motion for summary judgment determining the validity of the gas purchase contract.

The court has signed the foreclosure documents, on April 7, 1986, and the foreclosure sale is scheduled for May 28, 1986. The court also denied a motion for reconsideration filed by Natural Gas Pipeline Company. Natural has agreed to pay all but a disputed $209,000 within 3 days of the court's denial of their motion. ANR and Tenneco have paid all monies owed for principal and/or interest for SNG delivered from July 1 through December 31, 1985. Transco is claiming a disputed credit for $395,000 but has paid the rest of what it owes for that period. All four pipeline companies have paid for SNG delivered in January and February 1986 at the Gas Purchase Agreement rate.

Three of the four pipeline companies (all except ANR) have indicated they will appeal the ruling of the court of January 14, 1986.

Financial

Prior to the court decision of January 14, 1986, which ruled the Gas Purchase Agreement valid and enforceable, our estimates were that additional federal financing of the project would have been required in March 1986 for continued operation. With the payments of ANR Pipeline Company and Tenneco for earlier gas deliveries, and the payment for January and February 1986 gas deliveries at the Gas Purchase Agreement rates by all four pipeline companies, sufficient working capital has been infused into the project to preclude the necessity for additional federal financing at this time.

DOE published a notice in the Federal Register on February 13, 1986, soliciting "Statement of Interest" and "Informational Proposals" from public and private sector organizations for acquiring the Great Plains Coal Gasification Plant. Nine responses were received by the April 4, 1986 deadline. DOE expects to analyze the Statements of Interest which were submitted in response to this notice to aid in the DOE's deliberations to determine the most appropriate means to secure a viable owner of the Great Plains Gasification Project in order to recover as much as possible of the principal and interest which has been paid pursuant to DOE's guarantee and to continue, for a sustained period of time, the operation of the gasification plant to produce substitute natural gas (SNG) and other product slates for sale in the marketplace. DOE's commitment to the management and monitoring of this project will end upon final disposition and transfer of title to the new owner of the plant and its assets.

QUESTIONS FROM SENATOR PETE V. DOMENICI

Question 13: What commitments will be broken as a result of DOE's withdrawal from the MHD program? From the Underground Coal Gasification program?

Answer: In June 1984, the Department of Energy restructured the MHD program. In a plan which was proposed at the request of Congress, the historic program, which focused on subsystems development, was redirected to a multi-year, cost-shared program targeted on proof-of-concept (POC) testing. The Department also agreed to share with the private sector participants the cost of a conceptual design of an MHD retrofit system. A privately funded, MHD/steam/electric retrofit plant was considered to be the next logical development step following the successful completion of the POC testing.

Because of budget constraints, the Department reassessed its priorities for fossil energy research and determined that other fossil energy technologies could contribute more directly to the Nation's energy needs within shorter timeframes, with lower Federal investment requirements and with significantly more cost sharing from the private sector. As a result of this reassessment, and in view of the changed Federal financial circumstances, DOE proposed to terminate the program and to turn over the Government-owned MHD facilities, valued at approximately $120 million, to the private sector for their use in developing the technology.

The termination of the MHD program will not result in any broken commitments, other than the termination of ongoing multi-year contracts. The Department has no existing commitments with other organizations or other governments which are predicated on the continued funding of the MHD program.

The FY 1987 budget request for the Underground Coal Gasification program does not preclude the Department from meeting all major programmatic commitments. This will be done through judicious use of existing appropriations and through the Cooperative R&D Ventures Pool. The former will address those activities in progress, and the latter will serve as a mechanism to pursue further research identified by industry as a necessary precursor to commercialization.

QUESTIONS FROM SENATOR PETE V. DOMENICI

FOSSIL ENERGY R&D

Question 14: What progress is being achieved to coordinate and integrate the research at Sandia-Livermore's Combustion Research Facility with that undertaken at INEL's Idaho Laboratory Facility?

Answer: Considerable progress has been made in the coordination and integration of research at Sandia National Laboratory's Albuquerque (SNL/A) facility with research sponsored at the Idaho National Engineering Laboratory, (INEL) at Idaho Falls. Specifically, under Fossil Energy's AR&TD program, the two laboratories are studying the pretreatment and treatment of coal by chemical and catalytic methods (at SNL/A) and by biological methods (at INEL). Coal pretreatment, by chemical, catalytic, or biological methods offers the possibility of modifying the coal structure. The treated coal could lead to cleaner fuels, either through combustion, or further processing, such as liquefaction or gasification.

Collaboration with the Sandia Combustion Facility at Livermore will be achieved at a later stage following production of these treated materials by the two different methods. Research managers from the three laboratories meet with regularity to discuss the coordinated research programs.

QUESTIONS FROM THE MAJORITY

PROGRAM DIRECTION AND MANAGEMENT SUPPORT

Question 1: Program Direction and Management Support has a budget request of $40.2 million, nearly 27% of the total Fossil budget. It seems to be unusually high. Would you explain why it is only reduced 24% from the FY 1986 appropriation, while Fossil R&D has been reduced more than 50%?

Answer: The funding for Program Direction and Management Support includes salaries, benefits and travel for headquarters and Energy Technology Centers personnel. It also provides for overhead expenses generic to the entire Fossil Energy program.

In addition to these costs, this funding provides for indirect costs in support of day-to-day project management functions for assigned programmatic areas. These costs provide for facility operations, maintenance, finance and administrative support.

While some of this budget does reflect a percentage reduction based on the total funding requested, the dollars for the in-house research programs at the Energy Technology Centers have remained relatively constant over the past few years. The in-house research programs establish a technical base for Fossil Energy, which is supplemented and enhanced by industrial, university and national laboratory research.

QUESTIONS FROM THE MAJORITY

COOPERATIVE R&D VENTURE POOL

Question 2: With oil prices dropping at an alarming rate, most of the independent oil and gas producers are already in trouble. Why do you think that the Cooperative R&D Venture Pool would attract any private funds? What assurance can be obtained that Federal funds are just displacing private sector funds which would be available anyway?

Answer: As indicated previously, because of the drop in oil prices, oil companies have fewer resources to apply to fully funding the cost of private sector R&D. Consequently, they may be more willing to pool what resources they have to address identified key research needs.

As with any R&D funding strategies, however, there can be no guarantee that some private sector funds may be displaced by government funding.

Through the Cooperative Agreement with the National Institute for Petroleum and Energy Research, the Department is engaged in cooperative petroleum research on a 60% industry, 40% Government cost-share basis. Also, cooperative research on a similar cost-share basis is being conducted with New Mexico Tech.

QUESTIONS FROM THE MAJORITY

COOPERATIVE R&D VENTURE POOL

Question 3: What advice are you looking for from Congress concerning the development of a viable, effective venture pool?

Answer: The Administration has proposed to the Congress to initiate a Cooperative R&D Venture program in FY 1987, as described in the FY 1987 budget submission. The Office of Fossil Energy is now preparing a document discussing the details of how the cooperative ventures should be structured, how they should operate, what they should contain, and the procedures for developing an appropriate joint venture. After the document is prepared, public comment will be solicited in an open public meeting to discuss the best approach for assuring the greatest likelihood of success. This information will then be used to finalize an approach and to issue a document inviting industry to propose venture participation with the U.S. DOE. Congressional input at every stage of this effort would be valuable. Congressional views on the strategy, objectives, and elements of the Cooperative R&D Ventures program, as described in the FY 1987 budget submission, would be very helpful as would Congressional comments on the planning document that is in preparation.

QUESTIONS FROM THE MAJORITY

ACID RAIN

Question 4: Mr. Drew Lewis recently issued a report on Acid Rain and called for $5 billion in an Acid Rain abatement program. The budget requests on coal preparation and flue gas cleanup are not in line with the environmental concerns. So, what is your comment on the report?

Answer: The Special Envoys' Joint Report on Acid Rain has been endorsed by the President, and although funding at the levels recommended in the report is not available now, the Administration will seek to provide, in the future, funding at the recommended levels.

QUESTIONS FROM THE MAJORITY

UNIVERSITY COAL RESEARCH

Question 5: On Page 10, you indicated approximately 20 new university projects relating to coal would be initiated. But you failed to mention there is an actual reduction by University Coal Research. Would you tell us what was appropriated in FY 1986?

Answer: The appropriation for University Coal research in FY 1986 was $5,622,000 under the provisions of Public Law 99-190. This will provide for approximately 30 new awards in FY 1986. The FY 1987 request of $4,000,000 will allow the funding of about 20 new grants in FY 1987.

QUESTIONS FROM THE MAJORITY

FOSSIL ENERGY R&D

Question 6: What is the rationale for shifting most of the R&D to DOE's technology centers? It seems we need to cultivate the R&D community in universities and labs. Would we narrow the R&D community and dissipate the R&D talent by consolidation of R&D efforts?

Answer: There has not been a shifting of R&D to DOE's technology centers. In fact, Energy Technology Centers in-house research funding remains fairly constant. As for the other categories, the National Labs are reduced by about 60% and the universities and industrial research programs are reduced by about 70%.

The in-house research program establishes a technical base that is supplemented and enhanced by industrial, university and national laboratory research. It should be noted that Fossil Energy maintains a very strong technical transfer program at the ETC's to help transfer appropriate technology to the private sector. Technology transfer is accomplished through such activities as program reviews, symposiums and conferences with strong private sector participation, the publication of numerous research articles and fact sheets, and through the maintenance of technical ADP data bases that are accessed by the private sector.

QUESTIONS FROM THE MAJORITY

FUEL CELLS

Question 7: Congress appropriated $35.4 million for Fuel Cells programs. And by January, we learned that $22.1 million of such appropriation has not been spent. The FY 1987 request is only $5 million. It is amazing that what Congress intended and DOE decided can be so far apart. Would you explain why there is $22.1 million in unspent funds?

Answer: Of the $35.4 million appropriated in FY 1986 for the Fuel Cells program, $1.4 million was sequestered by Gramm-Rudman-Hollings. The original proposed deferral of $22.1 million included $17.3 million for phosphoric acid systems, $3.8 million for molten carbonate systems, and $1.0 million for advanced concepts. However, this deferral has been revised and the Department has, at present, deferred $10.2 million including $5.6 million for phosphoric acid systems, $3.8 million for molten carbonate systems, and $0.8 million for advanced concepts. These deferred funds, in addition to other proposed deferrals, will be used to offset the total FY 1987 Fossil Energy R&D program budget request of $150.1 million. In addition, $9.3 million of phosphoric acid systems FY 1986 appropriations for the 7.5 MW technology development is proposed for rescission instead of being deferred as previously reported. The majority of the deferrals and the rescission are related to phosphoric acid fuel cells (PAFC). In the PAFC program, the Department is continuing development of the 11 MW stack configuration "A" with the International Fuel Cells Corporation (IFC) in FY 1986 and FY 1987 utilizing existing funds. In addition, the competitive procurement for configuration "B" cell stack R&D will be funded using FY 1985

unobligated funds. For the molten carbonate program, the IFC contract for external reforming is funded to completion using FY 1986 funding. The Energy Research Corporation's direct fuel cell project is funded through the current contract period (Sept. 1, 1986) using FY 1985 funds. In addition, a competitive procurement will be issued in late FY 1986 to continue development of external and/or internal reforming molten carbonate stacks using FY 1986 funds and technology development continued into FY 1987 using FY 1987 funds.

QUESTIONS FROM THE MAJORITY

PETROLEUM RESEARCH

Question 8: Nearly all research on petroleum by National Labs are zeroed out. Would you explain the policy behind such a drastic move?

Answer: While it is true that no funding was requested for National Labs in the petroleum budget for FY 1987, the Department believes that the FY 1987 budget request for Fossil Energy R&D continues a balanced petroleum research program. A total of $1,811,000 has been requested for Advanced Process Technology programs, $4,484,000 for Enhanced Oil Recovery programs, and $3,595,000 for Oil Shale programs. This represents a total FY 1987 petroleum request of $9,890,000 for basic research activities. Most of this funding will support in-house R&D efforts conducted by NIPER and the Energy Technology Centers.

In addition to the previously described basic research program, a new funding mechanism, the Cooperative R&D Ventures Pool, will be utilized to fund the Fossil Energy applied R&D program. The primary purpose of this $12.5 million pool is to support industrially-performed R&D focused on the Fossil Energy extraction technologies. However, this does not exclude participation by the national labs, the Energy Technology Centers, or universities.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

CLEAN COAL TECHNOLOGY PROGRAM

Question 1a: Following the budget hearing before the Energy Committee with the Secretary, I submitted questions for the record concerning the Clean Coal Project. In answer to one, Secretary Herrington said, "It is DOE's intention to recover an amount up to the Government's contribution to the project from net revenues from the operation (after operating costs) ..."

What does "net revenue ... (after operating costs)" mean?

Answer: In Section VI.6 of the Clean Coal Technology PON, "net revenue" is defined as the difference between revenue and operating costs.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

CLEAN COAL TECHNOLOGY PROGRAM

Question 1b: Do operating costs include the cost of capital, such as some annualized figure representing return on the company's investment in the project?

Answer: Operating costs consist of the non-capital production costs and capital-related expenses as recognized and allowed by the Internal Revenue Service. Operating costs do not include a return on the company's investment in the project.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

COOPERATIVE R&D VENTURES POOL

Question 2a: Also, in response to an earlier question, Secretary Herrington described the R&D venture pool concept as following the terms of the National Cooperative Research Act of 1984. That Act provides industry with a useful tool in developing research partnerships and greater certainty of treatment under the anti-trust laws.

In order for companies to use the provisions of the National Cooperative Research Act of 1984, they must make an informational filing with the Department of Justice. Is it your intention with the venture pool idea, for companies to follow the procedures of that Act (i.e., require a filing prior to participation), or are you merely suggesting that the Department will use the general guidance on R&D ventures as a model for your own selection criteria?

Answer: The Act provides industry with greater flexibility in developing research partnerships in terms of obtaining relief from anti-trust laws. The Department will utilize the Act as general guidance on R&D ventures and take advantage of its provisions to maximize the probability of success of the proposed Cooperative R&D Ventures program.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

COOPERATIVE R&D VENTURES POOL

Question 2b: With regard to participation in the venture pools, is it intended that government be co-participants, or will the program direction be solely in the control of the private participants?

Answer: It is anticipated that the Government will be a co-participant in the joint ventures.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

FOSSIL ENERGY PERSONNEL FLOORS

Question 3: Public Law 97-257 as amended by Public Law 98-369 mandates a Fossil Energy personnel floor of 700. You have proposed a budget that assumes repeal of the floor. How do you intend to fund the Fossil Energy personnel in light of the fact that you have not requested such an action by the Congress?

Answer: The staffing levels proposed in the FY 1987 budget request assume repeal of the floors. It is expected that legislation will be requested in FY 1986 to eliminate the congressionally mandated floors. Therefore, the funds requested in the FY 1987 budget request are adequate to fund the requested personnel levels. Fossil Energy will, however, comply with the employment floors as established in P.L. 98-369 until such time as Congress repeals them. The FY 1987 requested FTE budget levels reflect the minimum number of personnel needed to effectively manage and provide oversight of the proposed balanced Fossil Energy R&D program. The current legislative restrictions on employment reduce management flexibility to adjust and reassign staffing to achieve maximum effectiveness.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

PRIVATIZATION

Question 4: Does this year's massive reduction of the Fossil Energy budget, coupled with the venture pool concept signal a move towards full "privatization" of the fossil energy research area?

Answer: A move towards full privatization is not anticipated in the fossil energy research area. As part of the Administration's effort, however, to defederalize government functions which should more properly be performed by the private sector, the following Fossil Energy activities have been identified as candidates for divestiture:

- o Naval Petroleum Reserves
- o National Institute for Petroleum and Energy Research (NIPER) Facility
- o Great Plains Gasification Plant

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

FOSSIL ENERGY R&D BUDGET

Question 5a: You make the statement in your testimony that the proposed 73% cut in Fossil Energy technologies represents "its fair share in helping to bring federal spending under control" ... and contributing "to a future of continued economic growth."

Please describe for me how this massive cut represents a "fair share" when the overall departmental budget has not been reduced?

Answer: We believe the FY 1987 budget request for Fossil Energy represents the proper and fair balance between maintaining a strong technology base R&D program and recognizing the serious national budget deficit.

QUESTIONS FROM SENATOR JOHN D. ROCKEFELLER IV

FOSSIL ENERGY R&D

Question 5b: Please give me your view of whether and to what extent fossil energy technologies will contribute to economic growth in years to come? How much coal fired capacity will need to be built, and at what cost? What percentage of future generating capacity will rely on coal as a source fuel?

Answer: Fossil energy technologies, both supply and utilization, are expected to play an important role in the national economy for years to come because the U.S. is expected to remain highly dependent on fossil fuels for the foreseeable future. For example, the projections made for the current National Energy Policy Plan (NEPP) show that fossil fuels accounted for 87 percent of primary energy consumed by the U.S. in 1984, and are expected to still account for 82 percent of consumption in the year 2000, and 79 percent in 2010.

The NEPP projections reflect a 2.7 percent/year economic growth between 1984 and 2010, and it is expected that new fossil energy technologies will contribute significantly to this growth. We have not seen a credible quantitative estimate of the size of this potential contribution due to the many uncertainties and complexities. However, there is anecdotal evidence to suggest that the contribution is real.

For example, as outlined later in this response, on the order of 300 GWe of new coal-fired electric capacity may be needed by 2010, which would double today's coal-fired generating capacity. Advanced technologies, such as integrated

gasification and combined cycle (IGCC) are expected to reduce production costs and environmental emissions. A recent cost analysis by the Electric Power Research Institute (EPRI) suggests that IGCC using emerging technology (not considering potential advances from Fossil Energy R&D underway) could reduce busbar electricity costs by 15 percent versus conventional coal technology (EPRI AP-3980, Page S-11, March 1985). IGCC is one of a number of utility oriented technologies that have received Fossil Energy support.

Other Fossil Energy R&D is expected to produce significant benefits in the future, but the size of these benefits is dependent on factors such as how fast oil and gas prices go up in the longer term, and whether future environmental legislation will necessitate the retrofit of existing plants or require a new generation of improved environmental control technologies for new plants.

Relative to the quantity and cost of future new coal-fired capacity, the NEPP projections show utility coal consumption more than doubling between 1984 and 2010. This means that the current coal-fired capacity of 300 GWe would <u>at least</u> double to 600 GWe, which assumes that no existing plants retire and that capacity factors for existing plants do not degrade over time. Using 1986 dollars, 300 GWe would require a capital outlay of around $330.0 billion dollars.

According to the NEPP projections, in the year 2010 coal will provide 60 percent of the total energy inputs used for electrical generation.

QUESTIONS FROM SENATOR WENDELL H. FORD

Naval Petroleum Reserve

Question: The Naval Petroleum Reserves at Elk Hills is part of a unitization agreement with Chevron. No major decisions are made without consultation with Chevron. is that right? Has DOE had any discussions with Chevron about selling Elk Hills? If you were serious about selling Elk Hills, wouldn't you have discussed this with them before now?

Answer: The Department has not yet submitted a proposal to the Congress for the sale of the Naval Petroleum Reserves, nor have decisions been made on the timing or method of such a sale. While formal discussions have not yet been held with Chevron, we expect to discuss our plans with them over the coming months as we draft a legislative proposal.

Question: The Holifield tables indicate that DOE did not propose selling the Naval Petroleum Reserves, but rather sale of the NPR was an OMB initiative. Is this correct?

Answer: The proposal to sell the Federal government ownership interest in Naval Petroleum Reserves No. 1 and No. 3 is being made as a part of a government-wide initiative to transfer to the private sector certain business-type activities which no longer serve a uniquely public purpose. The Department's FY 1987 budget request to the President was formulated before the government-wide initiative was announced and therefore did not comtemplate the sale of the Reserves in FY 1987.

QUESTIONS FROM SENATOR WENDELL H. FORD

GREAT PLAINS

Question 2a: What are your plans with respect to Great Plains? Will you sell it, auction it or what?

Answer: On February 13, 1986, the Department published a notice in the Federal Register asking public and private sector organizations to express their interest in acquiring the Great Plains Coal Gasification Plant. Nine responses were received in response to the Notice of Interest. The responses will give the Department the opportunity to consider which of several options for disposition of the facility would be the most appropriate and advantageous for both the citizens of North Dakota and the U.S. taxpayer. The next step in the process would be to request formal proposals.

The Department's objectives are threefold. We want to transfer ownership of the plant and remove the federal government as a direct competitor in the synthetic gas production business. We want to recover, to the maximum extent possible, those funds provided by the U.S. taxpayers to cover the default of the original plant owners. And we want to assure continued long-term operation of the plant to avoid disruptions to the local economy and to capture the benefits to the national energy supply system associated with extended plant operations.

QUESTIONS FROM SENATOR WENDELL H. FORD

GREAT PLAINS

Question 2b: Could foreign interests, such as the Australians, buy the plant and move it?

Answer: The Department will make every effort to assure that a good faith effort will be made to continue long-term operation of the plant in North Dakota. It is possible that foreign interests could purchase the plant. However, we believe that the additional costs of several hundred million dollars to the purchaser for disassembling and relocating the plant to a distant location would make it impractical. If foreign interests make a successful offer to purchase the plant, we believe that it is more likely that they would operate the plant in North Dakota in order to train their own technicians and to collect operating experience. In addition, a foreign purchaser could transport samples of their own coals to North Dakota and conduct demonstration tests in the existing facility, in a manner similar to that which was done by American Natural Resources Company which transported North Dakota lignite to SASOL (in the Union of South Africa) in the late 1970's.

QUESTIONS FROM SENATOR WENDELL H. FORD

GREAT PLAINS

Question 2c: Will there be a minimum bid requirement?

Answer: The Department wants to recover, to the maximum extent possible, those funds provided by the U.S. taxpayers to cover the default of the original plant owners. At the present time, the Department is estimating the market value of the plant, while accomplishing sensitivity analyses under various economic scenarios. At this time, it is not possible to state whether a minimum bid requirement will be established.

QUESTIONS FROM SENATOR WENDELL H. FORD

GREAT PLAINS

Question 2d: Could the original owners come in and bid for it?

Answer: In the event the Department elects to dispose of the plant by a formal competitive process, companies that were partners in the Great Plains Gasification Associates will be allowed to participate.

April 1, 1986

Honorable Pete V. Domenici
Chairman
Energy Research and Development Subcommittee
United States Senate
Washington, DC 20510

Dear Senator Domenici:

The following are the answers to your questions in your letter of March 26, 1986 regarding the March 17 hearing:

Question: Could you elaborate on the reasons why Japan has chosen to market a low-performing, high-maintenance gas heat pump in the U.S.? If the U.S. prototypes are clearly superior to the Japanese units in terms of performance, why isn't someone here marketing our units?

Answer: As best as we can tell, the Japanese have two aspects to their strategy. The first aspect is that of market presence and establishment of needed sales and service relationships. Even though their first equipment might not be viable for broad market penetration, it does give them the aura of being "first". It has created a demand on the part of gas companies to have one or more to field test for themselves. This, in turn, gives the Japanese the opportunity to establish the needed personal relationships and sales, distribution, and service relationships needed to conduct the overall business. Therefore, when better equipment is available, they can simply implement it into the marketplace through these established channels. The second part of their strategy has to do with the world markets. Field testing, anyplace, gives them needed operational data to upgrade the equipment. There are also many parts of the world where the characteristics of their first equipment may well be acceptable to the marketplace. As to the second part of your question, we in the United States have made the decision not to "productize" our prototype equipment until it has met, in the laboratory, a series of specifications agreed upon by the gas industry and the contractors. Therefore, the several operating prototypes at contractors' facilities are not yet considered to be ready for field or market testing. Under these circumstances, the private sector still considers the American technologies to be too risky for private investment. The American candidates need to be strengthened and accelerated to the point where the private sector will pick them up.

Question: You have identified a 3- to 10-year time frame as the appropriate development period that projects undertaken by DOE should take, especially with respect to Industrial Conservation Programs. Do you think that DOE is following this rule of thumb? Or are they using shorter time frames? Longer time frames?

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Answer: When DOE first began as the Energy Research and Development Administration, the Industrial Conservation Programs were set up to identify those high potential benefit items which could be accelerated into the marketplace through government involvement. The time frame generally addressed by these first efforts was a 3- to 10-year one, that being the time between when the government program was started and when the product could be ready for marketing and sale in a purely commercial sense. This strategy paid off handsomely as may now be seen by examining the results of those early programs, as I have exhibited in my written testimony. At present, this strategy has been discarded and replaced by one of doing "long-term, high-risk" R&D which, unfortunately, has really become a program of not knowing when, if ever, the technologies addressed may become viable but certainly well beyond a ten-year horizon. This has left a void in the three-to-ten year time frame. The payoff is too far away to expect industry to finance the efforts, and the time frame is too near for present DOE thinking. This presents a beautiful opportunity for nations such as Japan to capitalize on candidate technologies in this time frame. If the taxpayer is to reap any benefit from his investments in these programs, the emphasis needs to return to that 3-to 10-year time frame originally addressed.

Question: Since the Army and the Air Force are especially interested in Stirling engine applications, are they contributing any funds towards the development of this engine? With DOE's shift toward jointly-funded programs, it seems entirely appropriate that the Defense Department become a fiscal co-sponsor of this research and development program.

Answer: We would agree entirely. To put this answer into context, one must realize that, prior to the present DOE development program, Stirling engines were thought of as little more than laboratory curiosities. It has only been in the last year or so that the propulsion community has become aware of the tremendous progress that the technology has made through the DOE program. As a result of this new awareness, both the Army and Air Force have begun small programs to evaluate MOD I engines in a generator set and in an Air Force van. Hopefully, these programs will grow and the military will become an increasing entity in the funding structure of Stirling development. However, we feel that much of this will depend upon the success of the present MOD II program, since the MOD II is the first Stirling engine configured much as common production engines are configured. Should the MOD II design prove successful, we expect dramatically increasing participation from a number of other government and private entities. The MOD II effort is scheduled for completion at the end of 1987.

We thank you for the opportunity to present our testimony to your Subcommittee, and we hope that in the near future we can dramatically demonstrate the successful results of all these years of effort.

Sincerely,

Lloyd R. Lawrence, Jr.
Vice President

/mf

RDA

R&D ASSOCIATES
Post Office Box 9695
4640 Admiralty Way
Marina del Rey, CA 90295
213 822-1715

April 2, 1986

Senator Pete V. Domenici
Chairman
Senate Energy Research and
Development Subcommittee
Dirksen Building - Room 317
United States Senate
Washington, D.C. 20510

Dear Senator Domenici

I am most pleased to provide answers to the questions asked in your letter of March 26 in regard to my testimony before the Subcommittee.

(a) Q: To what extent is the $1,500 per kilowatt cost estimate for "Mist Lift" OTEC plants based on actual experimental results, and to what extent is it based on theory.

A: The power plant design that yielded the estimated cost of $1,500 per kilowatt was based on the formation of the mist at an initial specific volume of 500 liters per kilogram, and expanding this mist to a specific volume of about 2,000 liters per kilogram. The efficiency of coupling the thermodynamic work of the expansion into lift of the mist was taken to be 80%. This coupling efficiency has been confirmed by experiment over the range of specific volume from 1000 liters per kilogram to 2,500 liters per kilogram. The extrapolation of this coupling efficiency to the range from 500 liters per kilogram to 1000 liters per kilogram is presently based on theory. Thus it would be fair to say that the estimate is based about two thirds on experiment and one third on theory.

A proposal to conduct experiments in this extended specific volume range with the Mist Lift apparatus at Keahole Pt. was submitted to the Solar Energy Research Institute in the fall of 1983. So far funds to accomplish this and related Mist Lift development work have not been available.

(b) Q: If $1,500 per kilowatt is a realistic figure, why isn't industry developing the technology on its own?

A: The power generation industry is without incentive. They invest only in sure things. Then the State Public Utility Regulating Commissions set the power rates so that the Utility gets its costs back and a guaranteed profit from the consumer. If a Utility gambles and loses the stockholders pay. Recall the financial disasters experienced by some utilities in the construction of nuclear power plants. If a development is successful, and leads to much less costly power, the ratepayers get most of the benefit, and the stockholders not much.

The power equipment manufacturer has some incentive, but at present the market looks small. The large power using industries have grown up in areas well supplied with hydroelectric power or inexpensive fuel, but most such areas do not have the Ocean Thermal resource. Many tropical countries are endowed with the Ocean Thermal resource, and could use inexpensive power, but are too poor at present to look like good customers to an equipment manufacturer.

Sincerely yours,

Stuart L. Ridgway

Stuart L. Ridgway
Program Manager
Mist Lift OTEC Process

Dr. Bernard S. Lee (President, Institute of Gas Technology)

a. Does IGT do any contractual research work with DOE--similar to the joint programs between GRI and DOE?

How many of your programs are in jeopardy because of DOE's proposed budget cuts in FY'87?

As a contract research organization, operating for over 43 years, IGT does work as both a prime contractor and subcontractor to DOE. Over the years a number of our research projects have been funded as joint programs under DOE in partnership with GRI. Since IGT is a not-for-profit institute our contribution to any joint research effort is through facilities and in-kind services.

At the present time, six IGT research projects are in jeopardy because of the DOE proposed FY'87 budget cuts.

b. Does IGT coordinate with GRI and AGA, as well as with DOE, so as to avoid duplication of research efforts?

Each year, IGT evaluates the DOE non-nuclear research and development budget from both a fiscal as well as a technical perspective. GRI and AGA in turn perform a similar evaluation. Taking into consideration the contribution to near-term gas technology research needs by the GRI budget, and based on the perception of the three gas industry groups of where there is a need for improvement in the DOE budget, the gas industry coalition makes its recommendations known to Congress.

While the three gas industry organizations do make a coordinated recommendation for changes in the DOE budget request, it is important to remember that each organization has a different function with respect to the gas industry. AGA is the actual "trade association" for the gas industry as a whole. GRI is the administrator of funding obtained through the rate base on volumes of gas sold through interstate pipelines which is set aside specifically for research. The GRI budget is regulated and approved by FERC. IGT is a not-for-profit organization which performs non-nuclear contract research recommended by the gas industry among others.

American Chemical Society

DEPARTMENT OF GOVERNMENT RELATIONS
AND SCIENCE POLICY

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4477

April 9, 1986

The Honorable Pete V. Domenici
Chairman
Subcommittee on Energy Research
and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Senator Domenici:

I am happy to provide the following written responses to your questions for the March 17, 1986 hearing record:

a) Question: In your statement, you say that Japan is heavily involved in coal research. Why is this important to Japan, considering that they don't have any coal resources, and would have to import every ton of coal they would utilize? Aren't coal transportation costs to Japan prohibitively expensive?

Answer:

As the supply of oil dwindles and the cost of oil rises, oil will be replaced by other fuels. Japan is heavily involved in a variety of coal research projects, presumably in preparation for the replacement of some oil uses by coal. The Japanese now import all their oil and will have to import almost all their coal or coal products, probably from Australia and China. Abundant coal reserves are much closer to Japan than are the middle eastern oil fields. Japan engages in cooperative coal conversion research with both China and Australia, so they may elect to import coal products rather than coal, thus minimizing transportation costs. Coal transportation costs to Japan are not prohibitively expensive, and high transportation costs simply increase the cost to which oil must rise before it becomes economical to replace it with coal.

b) Question: What do you use as your standard-setter with respect to fossil energy research?

Answer:

The standard-setter for requesting funds for fossil energy research is based on an estimate of what is believed to be an adequate level of support required to maintain an effective long-range coal research program--one which enables steady research progress and maintenance of a viable scientific community.

c) Question: Doesn't the presence of the recently authorized Clean Coal Technology program serve to more than offset the drop in coal research within DOE's fossil energy budget? Why or why not?

Answer:

I do not believe that the Clean Coal Technology Program offsets the drop in coal research within DOE's fossil energy budget. The Clean Coal Technology Program supports the final stages in process development and is designed to test the economic feasibility of coal cleaning processes for which the basic research had long ago been completed. This program is an aid to industry in bringing new coal cleaning technology to commercial operation. It is at the opposite end of the R&D spectrum from research and will provide no support for research, either fundamental or applied.

d) Question: How do you envision the "merit-based peer review process" to function? Who would be involved in this process? How would the "members" be selected? Are there any similar examples of this concept in other federally-sponsored research areas?

Answer:

I believe merit-based peer review operates well in NSF, NIH, and in much of DOE. With NSF, proposals for support of research usually are evaluated by five scientists, who are selected by an NSF project officer. The NSF project officer typically uses these scientists' evaluation of the scientific merit of the proposed work as a guide in making an award of federal funds. The NIH normally convenes a committee, whose members are selected by NIH, to evaluate and rank a large group of proposals. The DOE system is similar to that of NIH. DOE staff assembles a panel of scientists, who are judged to be expert in the research being evaluated. This panel then ranks the research proposals in order of scientific merit using criteria specified by DOE. I do not believe peer review should supplant or replace consideration of political issues and the will of the Congress, but should be an integral part of the selection process based on Congressional guidelines. However, I do believe that peer review should always be part of the process, since it appears to be the best way we have of ensuring the highest possible scientific quality.

In operation, I foresee that a research funding process involving merit-based peer review might function as follows: Congress decides that research on sulfur removal from coal should be studied and appropriates funds for this in the DOE budget. DOE would then issue a Request for Proposals in conformity with the Congressional guidelines. The proposals submitted would receive a preliminary screening by DOE to ensure conformity with the RFP. This would be followed by an evaluation of the scientific quality of the proposed research by a panel of experts assembled by DOE. Taking all factors into account, including scientific merit, DOE would then select the organization(s) to receive the award and execute the necessary contract(s).

I hope these comments are helpful. If I can be of further assistance, please let me know.

Yours truly,

John Larsen

John W. Larsen, Chairman
ACS Fuel Chemistry Division

APPENDIX II

Additional Material Submitted for the Record

PMAA

Statement of the

Petroleum Marketers Association of America

Before the

Subcommittee on Energy Research and Development

Committee on Energy and Natural Resources

U.S. Senate

Advocating a

Conservation R&D Program for Home Heating Oil

March 17, 1986

(329)

MEMBERS OF THE PETROLEUM MARKETERS ASSOCIATION OF AMERICA

The Petroleum Marketers Association of America represents the independent petroleum marketers who are members of these state and regional trade associations:

Alabama Oilmen's Association
Arizona Petroleum Marketers Association
Arkansas Oil Marketers Association, Inc.
California Independent Oil Marketers Association
Colorado Petroleum Marketers Association
Independent Connecticut Petroleum Association
Florida Petroleum Marketers Association
Georgia Oilmen's Association
Idaho Oil Marketers Association
Illinois Petroleum Marketers Association
Indiana Oil Marketers Association, Inc.
Petroleum Marketers of Iowa
Kansas Oil Marketers Association
Kentucky Petroleum Marketers Association
Louisiana Oil Marketers Association
Michigan Petroleum Association
Mid-Atlantic Petroleum Distributors Association, Inc.
Mississippi Petroleum Marketers Association
Missouri Oil Jobbers Association
Montana Chapter, Western Petroleum Marketers Association
Nebraska Petroleum Marketers, Inc.
Independent Oilmen's Association of New England
Fuel Merchants Association of New Jersey
New Mexico Petroleum Marketers Association
Empire State Petroleum Association
North Carolina Petroleum Marketers Association
Northwest Petroleum Association
Ohio Petroleum Marketers Association
Oklahoma Oil Marketers Association
Oregon Petroleum Marketers Association
Pennsylvania Petroleum Association, Inc.
South Carolina Oil Jobbers Association
South Dakota Petroleum Marketers Association
Tennessee Oil Marketers Association
Texas Oil Marketers Association
Virginia Petroleum Jobbers Association
Washington Petroleum Marketers Association
Western Petroleum Marketers Association
West Virginia Petroleum Marketers Association
Oil Jobbers of Wisconsin, Inc.
Wyoming Petroleum Marketers Association

The Petroleum Marketers Association of America is located at 1120 Vermont Avenue, N.W., Suite 1130, Washington, D.C. 20005. Telephone (202) 331-1198.

Statement of the
Petroleum Marketers Association of America
Before the
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U.S. Senate
Advocating a
Conservation R&D Program for Home Heating Oil

PMAA very much appreciates the opportunity to describe its concern over the proposed lack of funding for oil heat R&D in the Department of Energy's budget request for Fiscal Year 1987.

PMAA is a national federation of 41 state and regional trade associations representing 11,000 independent marketers of petroleum products, equipment and service. While almost all of these marketers are small businessmen, collectively they sell over three quarters of the home heating oil and half of the gasoline consumed in America today.

Example of R&D Benefits for Consumers

PMAA believes that federal research has been very beneficial to consumers of oil heat. For example, the oil heat program that was started in 1978 at Brookhaven National Laboratory is one of the most successful stories in federal research history. With an R&D investment of only $5 million, Brookhaven demonstrated the success of the flame retention burner that has become the industry standard for new oil heating equipment.

New flame retention equipment and retrofit devices for existing oil burning equipment are estimated to save consumers $1.5 billion through reduced oil usage by the end of the next decade. This amounts to one of the best cost/benefit ratios ever funded by DOE.

Proposed Oil Heat R&D

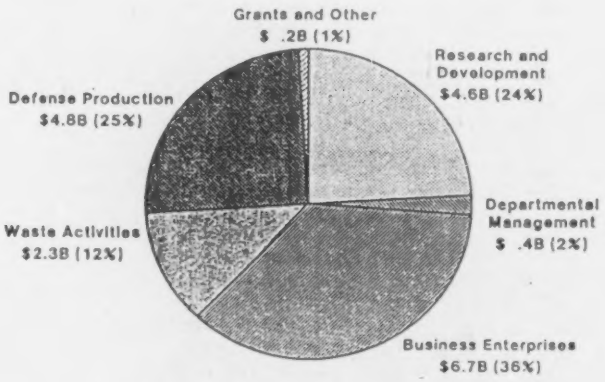
PMAA feels that there are several research projects that should be undertaken by DOE in FY87 that are equally as promising in terms of costs and benefits to 15 million oil heat taxpayers as the example just cited. These projects have been identified in a study being funded by DOE through Batelle Pacific Northwest Laboratories.

Attached to this statement is a detailed description and proposed funding level for these projects, which are summarized on the fourth and last page of this statement. Briefly, a total funding level of $1.9 million is required in three areas of activity:

- First, $1.05 million for efficiency advances on equipment such as heat exchangers and venting systems
- Second, $650,000 for advanced combustion and control, including pulsed combustion oil heating equipment
- Finally, $200,000 for technology transfer programs.

Oil Heat Slice of the Budget Pie

PMAA is aware of the Gramm-Rudman limitations on the budget, and supports efforts to reduce the deficit by reductions in federal spending. However, the pie chart on page 3 of DOE's Budget Highlights reveals Total Budget Resources of $19 Billion for DOE in FY87.



Total Budget Resources $19.0 Billion

The pie chart shows that the $.2 billion budget category of "Grants and Other" is barely visible as a 1% slice of the total budget pie, and that is over 100 times larger than PMAA's $1.9 million request for oil heat. This raises the question why taxpayer dollars are supporting DOE's multi-billion projects to produce electricity and natural gas from nuclear energy and coal, without any effort toward helping taxpayers as a user of oil heat.

Federal Role is Needed

The federal R&D for other fuels augments the work of the Gas Research Institute and the Electric Power Research Institute, which are funded by hundreds of millions of dollars in surcharges on electric and natural gas rates that are approved by federal and state authorities.

By contrast, local oil heat marketers have no exclusive sales territories and no government approval or means to impose R&D surcharges. Major oil companies, which produce and refine oil products, do not accept responsibility for any R&D activities on behalf of equipment manufacturers or any end users, including space conditioning, automobiles or airplanes.

Most manufacturers of oil heat equipment also make gas and/or electric appliances. With a relatively smaller sales potential in oil, it is understandable that equipment manufacturers commit their limited resources to the gas and electric equipment that is the focus of the government and utility research efforts.

Considering the Administration's policy calling for a balanced and mixed energy picture, Congressional support for this request would encourage an effort by DOE to develop a coordinated equipment R&D program for oil heat.

Budget Limitations

PMAA recognizes the budget limitations which are prevalent throughout the government, and PMAA supports efforts to reduce the deficit by reductions in federal spending. However, if DOE is going to continue any R&D programs at all, then it is only fair to the 18% of American taxpayers who heat with oil that oil heat get its tiny slice of the R&D budget pie. PMAA strongly urges the support of this Subcommittee for a necessary portion of DOE's total budget to continue an oil heat program with such an excellent and beneficial track record.

Research & Development Program For Oil Heat Technology

The following projects are critical to oil heating equipment technology R & D and can be initiated by DOE in FY 1987:

	Proposed Budget ($ thousands)
1. Equipment Efficiency Advances	$1,050
• Fuel Quality Variation and Combustion Efficiency (200)	
• Advanced Heat Exchangers (375)	
• Oil Burner Diagnostics (275)	
• Improved Venting Systems (Direct Vent)(200)	
-Development of the technical basis for high efficiency equipment applications to reduce heat loss	
-Reduction of institutional barriers	
2. Advanced Concepts: Combustion, Modulation and Dynamic Controls	$ 650
• Advanced controls for oil-fired heating systems	
• Improved oil burning technologies	
• Advanced combustion systems research, including pulsed oil heating equipment	
• Systems integration	
3. Technology Transfer	$ 200
• Technical training aids	
• Conferences/Symposia/Workshops	
• Accelerate the use of energy conservation options by establishing a consumer-oriented informational program	
TOTAL FY 1987 Budget	$1,900

Attachment for March 17, 1986 Statement by PMAA

Research & Development Program For Oil Heat Technology

RESEARCH PROGRAM

This section discusses a program addressing major research questions as identified by workshops, special planning surveys, and a considerable amount of past work done by related Department of Energy programs and by the American Petroleum Institute in the 1960's. This section outlines the research approach and research program.

APPROACH

The oil-fueled equipment technology project outlined here is meant to complement private sector initiatives. Operationally, this means maximizing industry involvement, with DOE national laboratories serving in management, testing research roles, and universities providing critical knowledge and fundamental research as well. Industry involvement is important for three reasons. First, industry is the appropriate place for hardware research, and a majority of the technical questions to be answered about oil-fired equipment involve working with hardware. Second, transfer of technology to industry is far more effective if industry is involved with the work from the beginning, either performing research or observing and providing feedback. In this project, each research area will include work on transferring the technology, starting from the early stages of work. Finally, there are a great many codes and standards applicable to oil-fired equipment, many of which can even affect applied research decisions. Manufacturers, who are well aware of these pitfalls, must help in generating awareness of such institutional and market factors.

The DOE national laboratory involvement covers the full range from basic research to doing tests on conceptual hardware. Most important, though, is their role as research managers: making sure the right projects are being done, and by the right people. In this project this role is especially important as much of the technological advancement will be borrowed from related fields, including both basic research fields and work done on gas heating equipment. The multiprogram national labs have the unique ability to work across fields in this way, and to make this approach effective.

This university involvement will be stimulated by well-thought-out requests for proposals and cooperation originating at DOE national laboratories. Not only will the university research directly aid in development of new technology, but the training of graduate and undergraduate students in the field will upgrade the technology in the long term. Universities are an integral part of this program.

RESEARCH ELEMENTS

This section consists of program descriptions for 8 research elements, grouped into three major areas: equipment efficiency advances, advanced combustion and control concepts, and technology transfer and education. This grouping is primarily for the sake of understanding, rather than managing, the program, as each of the research elements is quite complex and addresses fundamental problems with current oil-fired equipment and its use.

A) Equipment Efficiency Advances - this area loosely groups research areas immediately relevant to current equipment stock as well as future generations of oil-fired equipment. Work in these areas is expected to produce important results sooner than the more conceptual work in the next grouping.

Improved Venting Systems

Conventional oil-fired heating systems use a chimney for venting combustion product gases outside of the building. These chimney exhausts cause excessive heat losses, representing a significant efficiency loss, which could be avoided by developing alternative venting methods. Alleviating this loss may raise overall efficiency by 20% . Perhaps more importantly, new classes of high efficiency heating systems, which have lower exhaust temperatures, require the development of direct venting. Other aspects of such systems are being developed in other research elements in this paper. Primary research activities in this area include examining specific institutional and technical venting requirements and technical approaches, investigating the technical problems and application limits, and studying selected problems in the laboratory.

Advanced Heat Exchangers

Conventional heat exchanger designs for residential and commercial oil-fired boilers and furnaces predate the rapid fuel cost escalations of recent years. These designs result in significant heating efficiency loss during both steady state and transient operation. Many of these design shortcomings can be improved by applying advanced heat exchanger design principles to improve efficiency while reducing the size and cost of oil burners and furnaces. Combinations of such improvements could raise current equipment efficiencies by as much as 10% -- a cut in losses of 50%.

Performance improvements envisioned for future heat exchangers include:

- enhanced heat transfer rates and smaller exchangers
- low-mass construction for minimal heat storage
- variable heat output rates compatible with zoned distribution and other strategies where only part of the structure needed be heated at certain times.
- reduced flue gas temperatures, and even condensing flue gas operation to recover some of the latent heat of vaporization of the combustible gases.
- lower equipment costs for same or higher efficiency performance
- heat exchangers compatible with advanced pulse, catalytic or other combustion systems

Research leading to these improvements will examine innovative heat exchange processes and devices. Some of the fundamental problems to be tackled include pressure drop/heat transfer tradeoffs, flow stability, corrosion, new exchanger materials and construction methods, noise levels, and soot deposition.

Oil Burner Diagnostics

Ideal stoichiometric combustion requires that exactly the correct quantity of air (oxygen) is supplied to completely burn all the fuel. This theoretical condition rarely occurs in practice because some excess combustion air is required as a safety factor to compensate for incomplete fuel-air mixing, changes in air density and other uncontrolled variables that exist in real combustion systems. Oil burner flames are particularly complex and require special attention to assure that adequate combustion air is supplied by the burner to prevent smoke production. Adjusting oil burner air supply to produce low smoke levels is very important to prevent efficiency degradation in boilers and furnaces and it represents a delicate balance between smoke formation and excess air. This optimum setting varies with burner design features and is determined in the field during oil burner installation and periodic servicing. If all burners were operated optimally all the time, the substantial losses currently suffered because of degradation in operating efficiency could be minimized.

Advanced combustion diagnostics and smoke measuring techniques will form the technical basis for several important applications including:

- improved field test devices to permit achieving highest possible burner efficiency;
- in-flue monitoring/alarm devices to alert homeowners and building operators of the need for burner adjustment;
- possible automated feedback controls for residential and commercial burners;
- tools for development and proper maintenance of future low input and variable firing rate concepts, which require very precise adjustment and control.

These diagnostics will be developed by borrowing from techniques pioneered in fundamental combustion research at universities and national laboratories.

Fuel Quality and Efficiency

Fuel oil properties can have an important impact on fuel atomization, vaporization, combustion, thermal efficiency and emission of pollutants. Unfortunately fuel properties vary depending how and by whom they are made (cheap imported fuel oil, for instance, is typically of very low quality), and can also degrade during storage. Problems caused by this range from efficiency losses to equipment malfunctions and breakdowns. In addition, Department of Energy research indicates that there will be continued slippage in oil properties as crude feedstock becomes rarer and of lower quality.

Physical properties of importance to combustion efficiency include viscosity, distillation temperature, pour point, carbon residue and flash point. These depend on the detailed makeup of the oil, which is a variable mix of a large number of chemical fuels and trace elements. Even if physical properties stay the same, chemical differences (such as extra trace heavy metals) can degrade performance badly.

Research will quantify the effect of certain fuel quality parameters on fundamental fuel oil combustion processes. Key research elements include

investigations of effects of fuel property and chemistry changes on atomization and vaporization, mixing, and smoke production, application of these studies to burner designs, and evaluation of effects of storage on efficiency and pollutant emissions.

B) Advanced Combustion and Control Concepts - this area includes work of a longer term, more fundamental nature that the previous grouping, and includes concepts for new generations of equipment. Some of the work, particularly in control of equipment, is clearly relevant in the shorter term as well, however.

Improved Oil Burning Technologies

Fuel oil combustion is a complicated combination of physical and chemical processes that convert the chemical energy contained within the fuel into heated combustion gases. The sequence of important physical phenomena occurring at the burner include fuel atomization, fuel vaporization, supply of combustion air, fuel-air mixing, air swirl and recirculation, flame stabilization, and complete combustion reactions. This research element consists of a number of generic studies in this area; they actually underlie some of the other research elements, and form the technical basis for developing burners with improved performance.

Specific technical goals for improved burners include:

- improved thermal efficiency
- lower smoke levels
- reduced fuel firing rates
- variable fuel firing rates
- reduced sensitivity to fuel quality variations
- increased flame stability
- decreased pollutant emissions
- improved reliability
- lower maintenance requirements

Key research elements that will lead to a better understanding of fuel oil combustion processes and equipment include atomization research, fuel-air mixing studies, and the effect of combustion transients on overall performance with particular emphasis on smoke control techniques applicable to burner design. The research will be conducted as a combination of closely controlled laboratory-scale work and testing in experiments that simulate actual operating conditions.

Advanced Combustion Systems

New combustion processes such as puse and catalytic combustion hold great promise for improving the efficiency of oil heating systems and permitting the development of a new generation of heating equipment designs. They should permit more complete combustion, reduced pollutant emissions, enhanced heat transfer rates, lower on-cycle and off-cycle heat losses, and reduced equipment size and cost. Pulse and catalytic systems for natural gas have been introduced recently, as the products of considerable research. The pulse systems have substantially higher thermal efficiency than conventional systems, while the

catalytic systems permit new operational concepts such as zone heating systems distributed through a building. Development of such systems for oil though, involves solving further and perhaps more difficult research questions.

Research in this area will explore these new system concepts through development of computer models, design approaches, building of conceptual devices and characterizing them for important functional parameters, and further identifying benefits and drawbacks of such new approaches. For instance, the real potential for pulse oil-fired systems may be as a condensing flue gas system -- an incredibly efficient combination in which some of the problems of condensing operation are mitigated by the benefits of pulse combustion and vice versa! This work may utilize results from several of the other research elements, particularly diagnostics, heat exchangers and oil burning technologies.

Improved Control Strategies

Conventional control systems and strategies have not benefitted from recent advances in sensors, microprocessors and systems engineering. Burner on-off cycling causes significant heat loss during the burner off-period that reduces the overall seasonal heating efficiency of the unit. Because burner modulation is impossible with current designs heating systems turn on and off far more than ideal, and cannot be adjusted to only heat occupied portions of a building. Improved control of combustion equipment, once combined with knowledge of building and distribution system thermal control, will lead to up to 40% fuel savings, particularly when combined with improved burners that permit modulation.

Research needs for control strategies include work to understand the way buildings and their occupants interact with equipment as well as work on the best way to control the equipment itself. The former work is part of a separate ECEP project, especially insofar as it is independent of the type of cooling or heating equipment involved. Research areas under investigation here include strategies for controlling equipment based on the thermal and mechanical behavior of the burner, heat exchanger and other parts of the equipment. This requires measurement of thermal time constants of components and correlating these with heat losses in order to develop guidelines for the best possible control strategies.

C) The final grouping is critical for this type of large, multifaceted research effort, and has thus been put in a separate category. Actually technology transfer is an integral part of every research area discussed above; this effort has additional goals and funding over and above such work.

Education/Technology Transfer

Conventional oil-fired systems, though technically simple, require considerable attention in order to perform at their best. Although their best is not very good, the level at which they actually perform given haphazard and ill-informed attention is much worse. In the near term, as much as 25-30% fuel savings can be reached by simply coordinating educational efforts of the heating oil community. Department of Energy involvement, for instance, means a great deal, and costs very little. In addition, such efforts give researchers valuable

contacts within the user community that are the key to providing usable, effective new concepts.

These contacts will help facilitate technology transfer as research results are achieved, as it is axiomatic that the best transfer occurs between industrial and research practitioners rather than managers. Key educational and technology transfer activities will include a large number of laboratory visits, production of special documentation, and holding industry workshops. All such efforts will be tied to specific technical research elements outlined here.

PROGRAM RESOURCES AND MANAGEMENT

This section outlines possible program management and preliminary resource plans.

MANAGEMENT

The liquid-fueled equipment project should become one of several key elements of the Energy Conversion Equipment Program (ECEP), which is in the Office of Buildings and Community Systems in the Department of Energy. A decentralized management plan is used in ECEP, whereby the technical resources of the national laboratories are used for program management functions and performing research, while program direction and policymaking is the responsibility of DOE headquarters.

Brookhaven National Laboratory should have program management responsibilities for this oil-fueled equipment research. Brookhaven will issues Requests-For-Proposals, evaluate proposals, execute contracts and monitor contractor performance, and otherwise perform the bulk of the interaction with universities and manufacturers. It will also perform a variety of in-house research which it is best suited to do, and coordinate technology transfer on work done in-house and by others. Finally, Brookhaven will continually interact with DOE headquarters, serving as the primary information channel for program control as well. This activity is typical for ECEP and other DOE research programs.

RESOURCES

This project as outlined will develop a large number of improvements to current capabilities of oil-fired equipment and its use. Some of the planned improvements should be completed within one or two years; others will take longer. All work is expected to take place within a funding scenario of approximately $2 million per year in real dollars. Funding on specific research elements is expected to shift somewhat as various stages on the various elements progress and trade off against one another.

THE UNIVERSITY OF UTAH

DEPARTMENT OF FUELS ENGINEERING
320 W. C. BROWNING BUILDING
SALT LAKE CITY, UTAH 84112-1183

March 5, 1986

Honorable P. Domenici
Chairman Subcommittee Energy Research and Development
U.S. Senate
317 Dirkson Office Building
Washington, D. C. 20510

ATT: Mr. K. P. Lau

Re: DoE Fossil Energy Budget Hearings

Dear Senator Domenici:

The Departments of Fuels Engineering, Metallurgical Engineering, and Chemical Engineering of the University of Utah have been conducting research for the development of U.S. tar sands for the past 12 years (see chart). As far as we know, our program is currently the only active program in the U.S. researching mining and above-ground technology recovery. Over the past 12 years we have achieved notable success in developing the scientific and engineering data necessary for commercialization of this important resource. The faculty members working on the program possess extensive industrial experience and are highly regarded. We have been called upon frequently by government and industry to supply information for their studies and to assist in their decision-making process.

No less than a dozen major energy and engineering companies have visited our facilities to obtain information for in-house programs and for assisting in corporate decisions regarding leasing and development. At least one significant company merger can be directly attributable to the results supplied by our work. We have no good way of valuing other less tangible benefits. However, over 20 M.S. and PhD. degrees have been granted in our tar sand program and the list of scientific publications resulting from the program now number more than 60. The state of Utah, which with its major tar sand resources makes it the 2nd largest petroleum resource state in the union, has an active interest in tar sand development. Since 1981 Utah has matched $1 for every $2 in research funding provided by DoE for our program.

We have recently learned that the DoE budget proposed for FY '87 calls for no further funding of tar sand research. We feel that discontinuing funding of tar sand research would result in significant adverse impacts for the country. First, it must be understood that domestic tar sand resources are petroleum-like in nature and products from this resource are more readily refinable than would other unconventional sources of hydrocarbons. Tar Sands could contribute to

our nation's energy supply in the shortest period of time, but additional research is required before this will happen. Second, economics of commercialization do not appear to be necessarily the major constraint to development. A far greater constraint in our judgement is the fragmented lease positions in which logical development units have never been delineated. This has resulted in a situation, especially in Utah and perhaps elsewhere, in which leases are generally held by speculators with no research ability while major industry, with the research ability, does not hold the leases and has little incentive to either block up the leases or invest funds in research.

Third, the technological research needs relate principally to the variability in the resource, both geological and chemical. These variations prohibit direct adaptation of technology developed for Alberta, Canada resources. As a matter of interest, Alberta has consulted with us on various occasions regarding our findings to assist in their future developments. We feel there is a high probability that some of our technology will prove applicable to their developments.

The current DoE program, as modest as it is, represents the one focal point of information and expertise currently available on U.S. tar sands that could serve as a nucleus for future developments. Discontinuing funding would effectively stop tar sand research and would result in a disbanding of the expertise currently available. The state of Utah would also be effectively taken out of the program because Utah could not carry on significant tar sand research alone without the federal government contributing to this work.

In our judgement a slightly accelerated program from FY '86 would result in a commercial plant of modest size in as little as 5 years. The primary product would be asphalt which we feel is currently profitable. We have recently learned that the U.S. is importing significant quantities of asphalt produced from Canadian tar sands and there is an appreciable market for such products in Utah and surrounding states. Asphalt is expected to become an increasingly important commodity as our current generation highways require resurfacing. An unconventional hydrocarbon commercial plant would greatly assist our state and national confidence that such development could contribute to our nation's energy security.

It is our consensus that the current downturn in world oil prices is temporary and partly artificial and could portend a swing in the opposite direction of equally major proportions. Now seems to be the most opportune time to conduct the necessary research so that the technology is ready when needed. In our judgement the venture pool approach proposed by DoE will not work with tar sands. The research is not sufficiently advanced nor is information available for the ventures to be successful even if participants could be identified. If the base research program is discontinued there would be no central place for ventures to gather information. Maintaining the current research effort at a comparable level to FY '86, but shifting the focus slightly toward shorter term commercialization is the best way

to proceed at this time. It is our understanding that this recommendation is also consistent with that of the state of Utah.

We appreciate your consideration of our testimony and would be pleased to have this entered into the record for your committee hearings.

Sincerely,

Alex G. Oblad, Principal Investigator
Distinguished Professor of
Metallurgical and Fuels Engineering
Member, National Academy of
Engineering

Co-Investigators:

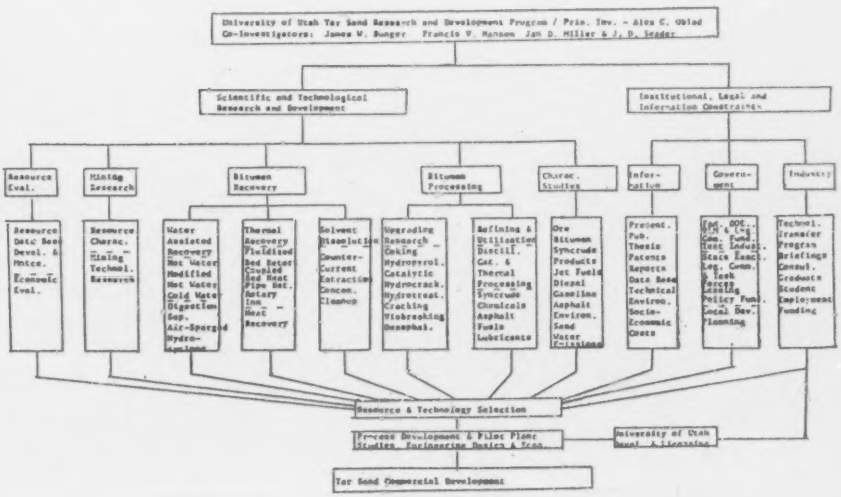
James W. Bunger
Research Assistant Professor

Francis V. Hanson
Professor of Fuels Engineering

Jan D. Miller
Professor of Metallurgical Eng.

J. D. Seader
Professor of Chemical Engineering

cc: Utah Congressional Delegation.


University of Utah Tar Sand Research and Development Program / Prin. Inv. - Alex G. Oblad
Co-Investigators: James W. Bunger Francis V. Hanson Jan D. Miller & J. D. Seader
Scientific and Technological Research and Development
Institutional, Legal and Information Constraints
Resource Eval.
Mining Research
Bitumen Recovery
Bitumen Processing
Charac. Studies
Infor-cation
Govern-ment
Industry
Resource Data Base Devel. & Minin. Economic Eval.
Resource Charac. Mining Technol. Research
Water Assisted Recovery Hot Water Modified Hot Water Cold Water Digestion Sep. Air-Sparged Hydro-cyclone
Thermal Recovery Fluidized Bed Reactor Coupled Bed Heat Pipe Rec. Rotary Ind. Heat Recovery
Solvent Dissolution Counter-Current Extraction Concen. Cleanup
Upgrading Research Coking Hydrotreol. Catalytic Hydrocrack. Hydrotreat. Cracking Visbreaking Deasphal.
Refining & Utilization Distill. Cat. & Thermal Processing Syncrude Chemicals Asphalt Fuels Lubricants
Ore Bitumen Syncrude Products Jet Fuels Diesel Gasoline Asphalt Environ. Sand Water Pollution
Present. Pub. Thesis Patents Reports Data Base Technical Environ. Socio-Economic Costs
Fed. DOE, DOI & Tax Con. Fund Trust Indust. State Encl. Leg. Cons. & Tech Focus Leasing Policy Fund. Legal Dev. Planning
Technol. Transfer Program Briefings Consult. Graduate Student Employment Funding
Resource & Technology Selection
Process Development & Pilot Plant Studies Engineering Design & Econ.
University of Utah Bond & Licensing
Tar Sand Commercial Development

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1987

(Nuclear Energy Programs and Nuclear Waste Activities)

TUESDAY, APRIL 29, 1986

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 10 a.m., in room SD-366, Dirksen Senate Office Building, Hon. Pete V. Domenici presiding.

Present: Senators Domenici, McClure, Wallop, Warner, Hecht, Evans, Johnston, and Ford.

Also present: Marilyn Meigs, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator DOMENICI. Good morning. The subcommittee hearing will come to order.

Let me first indicate for the record and to our friend, Senator Ford, that I will have to be on the floor at 10:30. I think Chairman McClure is going to arrive and take my place so that we can finish the hearing today.

We have Mr. Vaughan, Acting Assistant Secretary for Nuclear Energy, and Mr. Ben Rusche, Director of the Office of Civilian Radioactive Waste Management, as our leadoff witnesses, and then we have the Nuclear Regulatory Commission, Mr. Victor Stello, Executive Director for Operations. Military applications, we have two witnesses, Colonel Hess, and Colonel Heilman. We will try very hard, gentlemen, to accomplish the purposes of the hearing.

Let me open by saying good morning to everyone. Today we will be receiving testimony from the administration on various aspects of the Department of Energy programs, including its budget request for fiscal year 1987, that relate to the nuclear energy and radioactive waste disposal.

May I say at the outset that, while we may be tempted today to talk more about the Russian nuclear technology and safety standards, rather than the United States counterpart, we really ought to try to stick to the business at hand.

First, before we go on, I think this might be a good opportunity for us to take a moment to ask our expert witnesses if they have learned any more about the Russian reactor incident that may not yet be available to us.

We would be interested in what you know about the design features, safety features, safety standards of the Russian reactors compared to our own commercial reactors. If the Russian incident does involve a radioactive fire, why is that not a like scenario for United States reactors? Even if a fire were to develop, what is the likelihood of release into the environment, in view of the requirements for containment structures?

Do you, either of you, have any comments with reference to that?

Mr. VAUGHAN. Mr. Chairman, let me respond as succinctly as I can to those queries before we begin. First of all, let me say that the Department of Energy does not really have any detailed knowledge of what happened in the event in the U.S.S.R., beyond that which has been made available and broadcast on the public media and the wire services.

So we have no real additional specifics. I am sure that you are aware that the press, this morning, has been reporting that there is, as a result of some series of events unknown, a large graphite fire burning at the reactor, which has undoubtedly contributed to the atmospheric release of fission products.

Senator DOMENICI. Does graphite burn?

Mr. VAUGHAN. Yes, it will burn. There are degrees and quality of graphite which will inhibit its burning compared to other forms of graphite, and we have no detailed knowledge on the form of graphite which they use.

With respect to U.S. reactors, you have heard both this Department and the NRC articulate on numerous occasions what we believe are the keys to the very close attention paid to the safety, design and operation of U.S. reactors. Basically, a defense-in-depth concept in terms of having designed very carefully high-quality machines and inspected very carefully to ensure the quality is there.

The first line of defense, of course, is the integrity of the reactor fuel cladding. Beyond that, there are numerous safety and protective systems in the reactor which will assure protection and shut down in the event of abnormal events and, beyond that, the capability, typically, for emergency core cooling if even those protective systems should not do the job they are designed and intended to do.

And, third, beyond those stages, the capability for containment and control to prevent the release of radioactivity.

The large commercial reactors in this country are basically pressurized water-cooled reactors with water acting as both the coolant and the moderator, and of course, water does not burn. The Russian reactor that is the subject of interest is a water-cooled, graphite-moderated, open-cycle boiling water reactor, and so has quite a number of different design features and safety features built in it that are truly unique to the Soviet Union and are not common to the reactors in this country.

Senator DOMENICI. What about containment, overall?

Mr. VAUGHAN. The Russians are reported to typically not use quite the same level of containment that we do in United States nuclear powerplants and the degree to which that is a factor or not

a factor in this accident I think would remain to be seen depending on what the facts are as to the initial causes of the accident.

It is not implausible that there may have been some industrial explosion, or something of that nature, that could have caused them to lose both their power systems and their control systems. We will just have to wait to see what happened.

Senator DOMENICI. Just specifically, at the TMI accident, there was a partial core meltdown and there were large amounts of radiation released from the reactor core to the reactor building. Why were the offsite releases practically unmeasurable in this accident?

Mr. VAUGHAN. In large part, what we have learned from that accident scenario, as we have examined it in some detail in the 5 years since, is that inherent within the water-cooled reactor system was the capability that, even though the core had some partial melting, it was ultimately cooled and most of the fission products reacted and stayed in the system rather than being released outside the reactor system, first, and second, outside the containment building as a secondary backup.

Senator DOMENICI. Senator Johnston?

Senator JOHNSTON. Thank you, Mr. Chairman. I would simply like to make one statement, and I will ask a question later. I just want to make it so you can be thinking about it, and that is with respect to the MRS facility. There is a budget request here, but I do not think that budget request requests the authorization of the facility, and I think it should if we are going to be spending this kind of money. We ought to go ahead and make a commitment to have the MRS authorized as it, of course, can be as part of the appropriation legislation.

I simply make that statement and I will question you about it later.

Senator DOMENICI. Senator Johnston, and any other Senators, I thought maybe someone would have a question on the issue that I raised which was not the subject matter of the hearing, with reference to the Russian incident. Then, when we get to opening statements, to set into focus what our hearing is about today, which is not that, but nonetheless we are here, and I assume Senators might want to ask some questions on it.

That is why I yielded to you and anyone else who has a question on that will go next, and then we will go to our normal hearing.

Senator JOHNSTON. If I may just ask one question on that. I heard on the radio that the Soviets had asked for help in putting out the graphite fire. Have they asked us for that help?

Mr. VAUGHAN. Senator Johnston, the President made a statement this morning to the media while he was in Gaum, that the United States did have technical and medical expertise available which could be provided if it was needed. The details of the nature of the help and the specifics and whether or not it would be requested are still a matter under discussion as the day proceeds.

Senator DOMENICI. Senator Warner.

Senator WARNER. I have some questions directing the attention of the witness to the second repository issue which is of great concern in my State. Thank you.

Senator DOMENICI. Senator Ford?

Senator FORD. In keeping with your opening remarks, I want one question as it relates to the event in Soviet Russia.

The cloud is apparently moving. The Swedes said that their particles per million have increased 100-fold as a result of the rain they had yesterday. It is estimated that cloud will reach the west coast within the next 3 to 4 days.

How much concern do we need to have for that particular cloud? And will it continue based on its still burning, Mr. Secretary?

Mr. VAUGHAN. Senator Ford, obviously I don't have precise answers to those questions because the movement of clouds is somewhat speculative. My understanding is that the Swedes commented that, even though their levels of radioactivity had increased based on using very sensitive monitoring equipment, they did not believe that those levels posed any hazard to public health and safety. That simply is what I have heard on the media and not based on additional, special knowledge.

We obviously, through equipment and systems available to the Department of Energy at its national laboratories, will closely monitor the atmospheric conditions as they might relate to this country and if any action is warranted, take such action. But we do not anticipate any fallout to the degree it would be a serious public concern to this country.

Senator FORD. If this fire is not contained, not brought under control and continues to burn and continues to create a cloud, do you still think, in your best judgment, we would not have anything to worry about as it relates to health hazards?

Mr. VAUGHAN. That is my best judgment, obviously based on very limited knowledge. Several people have commented that the basic direction of movement of the cloud initially was counter to the normal winds and movements that are expected in that area. So it is not even clear it would continue to move in the same direction.

Senator FORD. I guess if they were burning coal, the only thing we would have would be acid rain. [General laughter.]

Senator DOMENICI. Senator Evans?

Senator EVANS. Thank you, Mr. Chairman. What do you know of the precise nature of the event, and have we asked specifically of the Soviets that kind of information? It seems to me that it is terribly important at this point to try to get them to be as candid as possible just on behalf of the safety of other nations that might be involved.

Have those kinds of questions been asked? What do we know of the precise nature of the event, and of the reactor, itself, in terms of its cooling capacities, just the nature of it, and if we have made those inquiries, what kind of response have we been getting?

Mr. VAUGHAN. Senator, let me answer that in two parts. First, just prior to your coming in, when I responded to a similar question from——

Senator EVANS. I am sorry I missed it.

Mr. VAUGHAN [continuing]. From Senator Domenici, we have little precise knowledge of the incident, other than that which has been in the public media. There has been no specific set of inquiries made, but those are being considered and will be considered as a part of any offer for us to provide assistance.

With respect to knowledge of the reactor designs, themselves, I commented previously that the Russian reactor is quite unique. It is a Russian reactor design of the water-cooled, graphite-moderated, and open-boiling water reactor cycle, which is unique to the U.S.S.R., built in the U.S.S.R., and to U.S.S.R. safety standards.

For example, the ignition of the graphite moderator and the causing of the fire which has been reported in the media, certainly would not be a common type of event for U.S. commercial pressurized water reactors where we use both water as the coolant and the moderator, and with quite a completely different set of design concepts and safety standards, which I described earlier in response to Senator Domenici's question.

We will, of course, continue to carefully evaluate design differences as we learn more facts, to make sure we leave no stone unturned as to lessons learned.

Senator EVANS. I guess more explicitly, do you believe we have sufficient information now to guide us in terms of any potential difficulties, fallout, problems that might impinge on this country? Do we need more? If we do need more, are we asking for it?

Mr. VAUGHAN. Are you using fallout in the sense of atmospheric dispersal, or are you using it in the sense of lessons learned from this event?

Senator EVANS. No, primarily the former. I presume as time goes on, the scientific community has a pretty good way eventually of learning things. I am more interested in the immediacy now of potential problems and whether we have all the information that we should be getting.

Mr. VAUGHAN. We, of course, have put systems in motion to monitor the atmospheric conditions to make sure that there aren't any problems to the health and safety of people in the United States. Beyond that, it will depend on additional, precise information coming out of the Soviet Union, which we don't yet have.

Senator EVANS. Do we know at this time whether there is any continuing discharge of radioactivity into the atmosphere?

Mr. VAUGHAN. The presumption from the press reports, which we believe to be accurate, is that the graphite fire is continuing to burn. It is possible that if it was a severe reactor accident, most of the fission products that have existed have quite possibly already been dispersed—because it is postulated that the event probably occurred last Saturday.

Senator EVANS. It seems to me, in that statement there is a lot of speculation. And I guess I am just curious as to why we have not made a direct inquiry. You may not get a direct answer, but I hope we have at least made the direct inquiry to elicit as much information as would be necessary or helpful for us in responding.

Mr. VAUGHAN. Those queries are underway, but we don't have the feedback at this time.

Senator DOMENICI. Senator Hecht?

Senator HECHT. Thank you; nothing, Mr. Chairman.

Senator DOMENICI. Senator Warner?

Senator WARNER. Let's look at this thing from the worse case hypothesis. Now you know basically the type of technology, the type of reactor. Given the worse case, could that generate any type of

radioactive fallout that could be detrimental the United States or other continental land masses?

Mr. VAUGHAN. Senator Warner, my opinion is that that is extremely unlikely.

Senator WARNER. So we should have no cause for alarm here in the United States. I do not believe we should have any great cause for alarm. I believe that our monitoring capability is sufficient that it would give us enough early warning if it were to occur.

I would note, again, that the comment that I understand the Scandanavian countries have made is, that although their very sensitive equipment monitored noticeably higher than background levels, notwithstanding, they believe that the levels they were monitoring posed no health and safety problems to their citizens.

Senator WARNER. The purpose of the question is that we should try and alleviate any fear among our own citizens here in the United States, if this type of accident could generate a situation that would be detrimental to the health and welfare of our people.

And your answer to that is no.

Mr. VAUGHAN. That is correct. In my best judgment. Obviously, I don't have all the facts at hand.

Senator DOMENICI. Senator McClure, did you have any questions on this first round. It was brought upon us not by plan here, as you understand, but by the events of yesterday?

The CHAIRMAN. I don't want to repeat what you have already asked in the excellent set of questions you asked, drawing some parallels, because I am afraid many people will try to draw parallels between this accident and U.S. experience. I think the point to be made and I think the point made in response to your questions was it is very hard to make comparisons because they are so radically and totally different. It is like comparing apples and oranges in very real terms.

I don't remember exactly, but I notice that the news report referred to an earlier nuclear incident in the Soviet Union, which as I recall was not associated with a powerplant at all.

Mr. VAUGHAN. My understanding of that incident, which I have not recently reviewed but have in the past, is that it occurred in the late 1950's and was more likely associated with a fuel processing plant, or something of that nature, as contrasted to a power generating source.

The CHAIRMAN. It was a materials production plant; could have been either for fuels or for military purposes. We are uncertain which, but it was not a powerplant.

Mr. VAUGHAN. That is my understanding, also, Senator McClure.

The CHAIRMAN. Again, apples and oranges and perhaps lemons—I am not sure.

We have nothing in this country that is identical with the Soviet plants, and our civilian powerplants all have both different design in terms of the reaction that occurs within them, and also in the—you have referred to safety standards. We have very strict standards in containment.

I notice, some people will immediately attempt to make some comparisons between this and what might have happened at TMI, or what did happen at TMI.

I think the fact will be that what we have perceived in Sweden, or what the Swedish officials have detected is radiation levels above the radiation levels that were measured at the fence at TMI, am I correct?

Mr. VAUGHAN. I think that is correct. It is our understanding, also.

The CHAIRMAN. So, comparisons are very difficult to make because they are so radically different in technical basis as well as in design, and as well as in the extent of the accident.

Mr. VAUGHAN. I agree with your analysis. I think it is a good, succinct analysis.

The CHAIRMAN. Thank you, Mr. Chairman.

Senator DOMENICI. Thank you. Senator Wallop, we were engaged in permitting Senators who might want to ask about the nuclear accident in the Soviet Union, before we got to the business at hand, if they had a question or two of the witnesses. We are completing that now. Does the Senator desire to ask on that issue, and then proceed to the——

Senator WALLOP. Mr. Chairman, I probably would but I would be certain to ask what has already been asked. I was up trying to see to it that we don't give away the entire store to the People's Republic of China without contemplating our ally and friend, Taiwan, in the Foreign Relations Committee—I missed this.

I am certain that as this unfolds, the dimension of it will grow rather than shrink. Is that fair—from what is presently being stated in the public press?

Mr. VAUGHAN. I think that that is probably a fair judgment.

Senator WALLOP. Also, I happen to see Mr. Medvedev, on the Today Show this morning, on which he made the statement that the Soviets did not use containment vessels because their technology was foolproof, much more sophisticated than ours.

You see how much you have been delaying us in the process of building nuclear powerplants in this country by making excess requirements like containment vessels. [General laughter.]

Seriously, I think that it demonstrates the strength of the American nuclear technology and the process that we have been undergoing.

Mr. VAUGHAN. We believe there are a lot of things that demonstrate that, not the least of which is, I believe, the very careful quality control we put into the design, manufacture and inspection of the equipment that goes in the plants.

We certainly don't have the data to know whether the Russians apply the same standards and levels of inspection. Some of their statements indicate that they can build the materials in these plants at almost any commercial facilities, as contrasted to the specialized facilities and specialized inspection techniques that we have. It might lead one to believe that if the standards are not as high, but certainly that is speculation on our part.

Senator WALLOP. Mr. Chairman, one last question. Do we know if this was a plutonium plant or a generating plant?

Mr. VAUGHAN. The press has reported that the plant was used for commercial power production, but perhaps with a concomitant purpose of making plutonium. We do not know that for sure, but

the design of the plant would indicate that that would be a possibility.

Senator WALLOP. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Chairman, could I ask unanimous consent at this point that my opening statement appear in the record following your opening statement?

Senator DOMENICI. Without objection.

Let me suggest to the members of the committee and the subcommittee, and in the presence of the chairman of the full committee; perhaps, Mr. Chairman, as the information on this accident becomes more familiar and available, it might be well that this subcommittee, or at your pleasure, the full committee, convene on short notice and try to, before this committee and for the American public, through this committee, learn any additional information that you find or I find in talking with the administration, ought to be presented.

I think it is urgent that all distinctions between what they have and what happened there and anything that has ever happened here be forthcoming in an official way, before a committee such as this, rather than we wait around for a long periods of time. I personally, subject to your direction, would ask the staff of this subcommittee to do that.

If the chairman prefers to do it in the full committee, I certainly will defer.

The CHAIRMAN. If the Senator would yield, I do believe it is important that we give the American public as much information as it possible for us to give, not only on what happened, but what implications that has for our programs, if indeed it has any. I would be happy to work with you and with Senator Johnston to make certain that this committee functions in such a way that we can give that kind of information to the American people.

Senator JOHNSTON. Mr. Chairman.

Senator DOMENICI. Yes.

Senator JOHNSTON. I just have two quick questions.

Senator DOMENICI. Would you defer on that? I have just been told that I have to go to the floor, so I understand Senator McClure will preside.

I have a statement with reference to the subject matter that we are going to discuss; that is, the scope of this hearing with reference to programs of the Department as they relate to their budget requests. I am going to ask that it be made a part of the record, and apologize for having to leave, but I understand, Senator McClure, that you have some time to preside in my absence. And I greatly appreciate that.

[The prepared statements of Senator Domenici and Senator McClure follow:]

STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Good morning. Today we will be receiving testimony from the Administration on various aspects of the Department of Energy programs, including its budget request for fiscal year 1987, that relate to nuclear energy and radioactive waste disposal. May I say at the outset that, while we may be tempted today to talk more about Russian nuclear technology and safety standards, rather than its U.S. counterpart, we really must try to stick to the business at hand. But first, before we go on, I

think this might be a good opportunity for us to take a moment to ask our expert witnesses if they have learned any more about the Russian reactor incident at Chernobyl?

(1) Please compare the design features, safety features, and safety standards, of the Russian reactors to our own commercial reactors.

(2) If the Russian incident does involve a radioactive fire, why is that not a likely scenario for U.S. reactors?

(3) Even if a fire were to develop somehow in a U.S. reactor, what is the likelihood of a radioactive release to the environment, in view of our requirements for containment structures?

Now let's get back to the business at hand. The nuclear programs for which the Department of Energy assumes responsibility represents a full platter of activities, ranging from remedial actions to advanced reactor concepts to military applications—and from the "front end" of the nuclear fuel cycle, that being uranium enrichment services, to the "back end" of the fuel cycle, that being the geologic disposal of high level radioactive waste.

The full spectrum of programs undertaken by the Department of Energy necessitates an airing of a wide range of views from Administration witnesses in order for this Committee to adequately assess the value and focus of each program element. It is for these reasons that we will receive testimony today from several Administration sources, including the Department's Office of Nuclear Energy, the Department's Office of Civilian Radioactive Waste Management, the Nuclear Regulatory Commission, the Strategic Defense Initiative Organization, and the Air Force.

We will begin with the testimony of Mr. Ben Rusche, Director of the Department's Office of Civilian Radioactive Waste Management. Mr. Rusche, it is a pleasure to have you here before us today—and let me add that, based on all I've heard about your activities of late, I think we may already have a "platter full" just hearing what has transpired in your Office over the last six months, without ever hearing what you have in store for us during the upcoming fiscal year! So we'd better get started.

STATEMENT OF HON. JAMES A. MCCLURE, A U.S. SENATOR FROM THE STATE OF IDAHO

Mr. Chairman, it is a pleasure to join you today to receive testimony from the Administration concerning the FY 87 budget request and program plans for the Department of Energy's nuclear activities.

I would like to start off by commenting that this country has a truly enviable record in nuclear energy research, development, and deployment. We now have more nuclear power plants in operation than any other country in the world. We forged the way for this and other countries to take full advantage of the nuclear option. (Unfortunately, one of the countries that did not follow our lead in technology or in safety standards is Russia, which I fear is regretting that decision today.) We now have the capability of resolving the few remaining safety questions concerning nuclear power plant operations—a feat that I'm not sure any other technology can hold a candle to. And we still maintain a cadre of scientific and engineering experts that can tackle any challenge that nuclear technology can offer.

As I study the Department's budget request and research program plans for fiscal year 1987, I am at the same time awed by the breadth of activities and amazed by the leanness of the dollar figures. The incredible array of research and development needs that will be met by a funding level of less than half of the amount we required only five years ago tells me one of two things: Either we had been squandering money in years past, when research areas were more narrow, or we are following ourselves today into somehow thinking we can spread our resources this thin and still maintain credible programs.

Let me pause at this point to add that I applaud the Department's goals in every single one of the program areas that are planned for in the '87 budget request. I am merely concerned that we are squeezing our resources so tightly that something will be lost in the pursuit of all these goals unless we are able to fund each and every one at the threshold level at which they will truly produce results. And so it is my hope that this Committee, in gaining a more thorough perspective on the Department's research elements, can perhaps help the Department to avoid the fate of spreading its resources too thin.

I might add that, with respect to the Department's other nuclear programs in the areas of remedial action, uranium enrichment, and nuclear waste disposal, I realize that these programs also have their own unique pressure points, and that responsible business management, careful allocation of resources, and attention to public

needs are crucial to the successful implementation of these programs. Indeed, it's times like this that the Department has exhibited in its pursuit of these responsibilities.

Senator DOMENICI. Senator Johnston?

Senator JOHNSTON. Thank you, Mr. Chairman. Gentlemen, I think it is important to point out here, the American reactors could not have a graphite fire, as apparently this is, because we don't use graphite and light-water reactors cannot have this particular kind of malfunction, at least as reported in the press.

Am I correct?

Mr. VAUGHAN. You are correct. There is one U.S. commercial reactor, a much smaller reactor, at Fort St. Vrain, which is a gas-cooled reactor, which is again of a different design. It does have a graphite moderator, but there are a number of other significant differences that don't make it at all like this particular Russian reactor.

Senator JOHNSTON. One more question: Do I understand correctly that after TMI, the studies indicated that even if the coolant had not been brought back on to cool the core, the core would not have fallen into the China Syndrome, and burned through the containment facility, but would have been contained. Did they make that conclusion?

Mr. VAUGHAN. Based on the knowledge we have in the examination subsequent to the accident, we believe that to be a true statement.

Senator JOHNSTON. So that we have full confidence, first, in the ability to bring on the emergency coolant, and even if that fails, we believe our design will both contain the core, and contain the polluted air, if that is the correct term——

Mr. VAUGHAN. I think fission product is the term you are looking for.

Senator JOHNSTON. Our design would contain the fission products within the facility.

Mr. VAUGHAN. We believe that to be the case.

Senator JOHNSTON. Thank you.

The CHAIRMAN [presiding]. Thank you. Are there any further questions on what we know about the Russian experience?

[No response.]

The CHAIRMAN. We will continue to monitor what is happening and hope to be able to provide any further information and may, indeed, seek further administration testimony with respect to what we know about that, or what we have ascertained.

We will begin with the testimony of Mr. Ben Rusche, Director of the Department's Office of Civilian Radioactive Waste Management.

Mr. Rusche, it is a pleasure, always to have you here before us today, and let me add that based on all I have heard about your activities of late, I think we may already have a platter full, just hearing what has transpired in your office over the last 6 months—without ever hearing what you have in store for us during the upcoming fiscal year, so we had better get started.

STATEMENT OF BEN C. RUSCHE, DIRECTOR, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT, DEPARTMENT OF ENERGY

Mr. RUSCHE. Thank you, Mr. Chairman, members of the committee. I am pleased to have an opportunity to talk to you about our fiscal year 1987 budget request and plans for the conduct of the program under the Nuclear Waste Policy Act of 1982.

I have prepared a rather complete statement, which I hope I might submit for the record.

The CHAIRMAN. It will be placed in the record.

Mr. RUSCHE. Thank you, sir. The program we have been carrying out, consistent with the priorities of the Nuclear Waste Policy Act, puts first priority on geological disposal of spent fuel and high-level wastes as America's solution to nuclear waste consideration.

The first such geologic repository is a part of a program which I will discuss in a few moments, but it is the element in the program which receives first priority.

The second priority is given to proceeding with monitored retrievable storage because of its potential for improving the overall system.

The third priority is given to siting activities related to a second repository, should the Congress decide that such a repository is eventually needed.

Neither the MRS nor the second repository are authorized for construction by the NWPA, but it is clear to us that the MRS offers the earliest and best means for assuring that the objectives of the NWPA are carried out.

Our budget request is under two funding areas: One, the Nuclear Waste Fund, which is financed by fees collected from owners and generators of spent nuclear fuel and high-level waste, and, second, a much smaller portion that is funded from the General Fund of the United States for Civilian R&D.

In keeping with the provisions of Gramm-Rudman, we have made adjustments in both fiscal year 1986 and in our planning request for fiscal year 1987. For fiscal year 1987, the fund expenditures proposed are $769.3 million compared to fiscal year 1986 of $499 million. The details of our request are provided in table 1 of my prepared statement and I will reserve discussion, perhaps to respond to particular questions.

Our request for the Civilian R&D Program is $6.5 million, compared to $16 million in fiscal year 1986. This funding level is consistent with our assessment of the best application of limited funds for generic research, and likewise, in table 2 of my prepared statement, are the details of that request.

We have, in addition, in the fiscal year 1987 budget, proposed that the Congress approve funding for MRS, and to the point that Senator Johnston addressed in his opening comment, take whatever such actions are appropriate to authorize our proceeding with MRS.

We have, therefore, before you today, in the President's budget, that request for an MRS.

Because of the peculiar circumstances that are before us, I would like to take an additional moment in this brief summary and focus

attention on MRS for perhaps reasons of eliciting questions and response.

I am sure you are all aware that I am limited in what I can say about MRS because we are currently enjoined by the Federal courts from submitting the formal proposal to Congress, required by section 141 of the NWPA on the need for and feasibility of one or more MRS facilities.

Therefore, I have to be very specific and point out that nothing I say today should be construed as being that formal proposal. Although I think I am at liberty to discuss with you in considerable detail the contents of the draft report which you received back in December, before the court action.

I believe I can say that having completed the needs and feasibility study, our analysis of the provisions of the NWPA and an evaluation of the programmatic options, we have concluded that an MRS facility located centrally to the major generators of spent fuel, and designed to be an integral component of the waste management system, would significantly improve the performance of the disposal system.

The facility should be designed and operated with the fundamental objective of protecting the health and safety of the public, the workers at the facility, and the quality of the environment. Such a facility would receive, consolidate and package spent fuel for bulk shipment to a permanent geologic repository. It would be licensed by the NRC and subject to both routine and unannounced inspections by the NRC.

It would be a shielded confinement and containment facility that would limit any releases of radioactive material to well below established regulatory limits, and its safety-related features would be based on available and proven technology in this country.

An MRS facility would allow DOE to separate a major part of the waste management process, that is, the acceptance, transportation, consolidation, and sealing in canisters, from the uncertainties about the repository, which attach primarily to the geologic aspects of the repository, and allow us to proceed immediately with detailed planning for, and implementation of, that separated part of the program at an earlier time.

Development and specification of a transportation system would also be advanced by several years because the approval of the MRS facility would allow specific routing, logistics, and equipment requirements for shipments from reactors to be determined up to 5 years earlier than would be the case if we have to wait for a determination of the first site finally by the President in 1991.

If development and construction could begin in the very near future, the accomplishments of the separable steps of the waste management process would significantly enhance confidence in the schedule for the operation of the total system.

We believe it would take about 10 years from the time of congressional approval and authorization to proceed and the time for such a facility to begin operation. By starting operation in 1996, and reaching full operations by 1998, the facility would allow the waste system to receive spent fuel at the full-scale rate 5 years sooner than does the system without an MRS facility.

Expenditures for the MRS project, from the time of congressional approval to the start of operations are estimated at about $970 million in constant 1985 dollars, of which about $700 million would be used for construction.

The annual operating expenses for the facility, which would employ about 600 workers, would be about $70 million, not including financial assistance and tax-equivalency payments.

All costs would be borne by the waste generators and paid for from the nuclear waste fund.

The cost of a total waste system, which includes an MRS, is estimated to be no more than 5 to 11 percent higher than that of a system without an MRS. We believe the cost and construction of an MRS are well worth that increment.

This does not include offset costs that we have been unable to determine with great precision because of the fact that for the remainder of the system there are a number of factors not yet determined.

Our request for MRS activities in fiscal year 1987 is $46 million. This request was submitted to the Congress in our regular budget proposal. Should we receive appropriate congressional action, both authorization and approval as you have suggested, the $46 million requested would be used primarily for site data collection and analysis, final design, regulatory compliance studies, and State liaison activities.

We have not, consistent with the injunction, submitted the formal proposal. However, our appropriation and authorization request is based on the earlier review documents in anticipation of the planned formal proposal that we had hoped to make in February and which were provided to you, the State, and other interested parties before the injunction was put in place.

If I may, I would like to take just 1 minute, finally, on the R&D program, because a number of you have elected to call to our attention a matter related to the generic program, particularly with respect to the Subseabed Research Program.

In preparing our 1987 budget request, under both the waste fund and the civilian R&D fund, we have tried to honor the spirit and intent of fiscal responsibilities as reflected by the various matters before the Congress. In so doing, we have had to make choices, just as you, indeed, are having to make choices.

Our choices, based on the three major priorities I mentioned earlier are, first, the first geologic repository; second, MRS; third, siting activities related to a second repository. And then, when we look at the civilian R&D budget, as you will note in my formal statement, we did not request funding for continuation of the subseabed disposal studies beyond fiscal year 1986.

We have, over the past several years, contributed funds from the general fund of the United States, to international efforts to determine feasibility of subseabed disposal.

We have not prejudged the technical feasibility of subseabed disposal in the future. In fact, if our budget proposal is accepted, we will continue to participate in such endeavors through international information exchanges and international involvement under section 223 of the act.

However, given the stringencies of budgetary requirements and the priorities that I have described, we believe that our most prudent R&D investments at this time are those involving cooperative demonstrations of at-reactor storage technologies, such as in Idaho, in cooperation with a number of utilities.

Our investments of time and dollars under the fund are, therefore, more appropriately directed to the three priorities that I have just mentioned earlier.

I would be happy to answer further questions, Mr. Chairman, on this or any other subjects related to the waste program.

[The prepared statement of Mr. Rusche follows:]

STATEMENT BY

BEN C. RUSCHE

DIRECTOR

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

U.S. DEPARTMENT OF ENERGY

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

APRIL 29, 1986

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to present the FY 1987 budget for the U.S. Department of Energy's (DOE's) Office of Civilian Radioactive Waste Management. I will highlight the major activities planned for FY 1987 under the Nuclear Waste Fund program, as well as under the Civilian Radioactive Waste Research and Development program and provide a current status of implementation of and plans under the Nuclear Waste Policy Act of 1982 (NWPA). Since the NWPA requires the annual submission of a triennial budget under the Nuclear Waste Fund, in my discussion of the FY 1987 Nuclear Waste Fund program, I will include estimates for FY 1988 and FY 1989.

BUDGET OVERVIEW

The NWPA created the Nuclear Waste Fund which is financed by fees collected from owners and generators of spent nuclear fuel and high-level radioactive waste. The FY 1987 budget request for the Nuclear Waste Fund is $769.3 million, compared to $499.0 million for FY 1986. The Nuclear Waste Fund budget estimate for FY 1988 is $863.0 million and for FY 1989 is $799.2 million.

Research and development (R&D) activities not financed under the Nuclear Waste Fund are funded under the Energy Supply R&D

appropriation in a program entitled Civilian Radioactive Waste R&D. The FY 1987 budget request for Civilian Radioactive Waste R&D is $6.5 million, compared to $16.0 million in FY 1986.

The FY 1986 budget request for budget authority funded by the Nuclear Waste Fund is summarized in Table 1. The FY 1987 Departmental budget request for Civilian Radioactive Waste R&D is summarized in Table 2. Under the Nuclear Waste Fund, the increased FY 1987 request will provide for extensive site characterization activities to begin exploratory shaft design and construction and to conduct intensive engineering tests and analyses to support the waste package and repository designs for the first repository. These activities will be conducted at each of the three candidate repository sites approved by the President for site characterization. DOE plans to formally recommend three sites for characterization to the President very shortly.

The increase in FY 1987 will also provide for preparation for site field investigations in crystalline rock under consideration for a second repository and design of the second repository. While construction of a second repository is not authorized by Congress, other activities involving siting and design of a second repository are required under the NWPA.

In addition to an increase in the budget related to the repository activities, the FY 1987 budget request also represents a significant increase over FY 1986 in activities related to Monitored Retrievable Storage (MRS), should Congress adopt the proposal required by Section 141 of the NWPA. The FY 1987 request of $46.0 million compared to $3.0 million in FY 1986

supports Congressional approval to proceed with activities that are critical to the deployment of an MRS facility. In that proposal, DOE will recommend the construction of an MRS to receive, consolidate and package spent fuel for bulk shipment to a repository.

The program proposed to be funded from the Nuclear Waste Fund puts first priority on the first geologic repository and the associated transportation, integration and management systems. Second priority is given to MRS because of its potential for improving the overall system, followed by a third priority to the second repository siting activity. Neither the MRS nor the second repository is authorized for construction by the NWPA, but it is clear that the MRS offers the earliest and best means for assuring that the objectives of the NWPA are carried out.

TABLE 1

FY 1987 CONGRESSIONAL BUDGET
NUCLEAR WASTE FUND
($in Thousands)

	FY 1986 Approp. 3/	FY 1987 Request
NUCLEAR WASTE FUND		
Repository Development		
o First Repository	$386,050	$541,800
o Second Repository	35,500	78,700
Monitored Retrievable Storage	3,000	46,000
Transportation and Systems Integration	21,275	33,375
Program Management and Technical Support	53,212	69,474
TOTAL	499,037	769,349
Projected Receipts		
o One mill/KHh fee	378,600 1/	420,500 1/
o One-time fee	2,300	2,500
TOTAL	380,900	423,000
Interest Income	118,000 2/	115,000 2/
TOTAL	498,900 2/	538,000 2/
Staffing Full-Time Equivalents (FTE's)	292	292

1/ Based on projected gross nuclear electricity generation reduced by 5% to approximate net nuclear electricity generation as a result of the recent Wisconsin court decision. (Wisconsin Electric Power Company, et al vs Hodel, 83-1066,84-8571 (decided December 6, 1985)). At the time of this budget submission, net nuclear electricity generation projections were not available.
2/ Based on average yield of Treasury security portfolio.
3/ After Gramm-Rudman-Hollings adjustment.

TABLE 2

FY 1987 CONGRESSIONAL BUDGET
ENERGY SUPPLY RESEARCH AND DEVELOPMENT ACTIVITIES
($ in Thousands)

	FY 1986 Approp.	FY 1987 Request
CIVILIAN RADIOACTIVE WASTE R&D		
Spent Fuel Storage Development	$ 8,554	$ 6,300
Alternative Disposal Concepts	7,207	------
Program Direction	303	200
TOTAL	$ 16,064 a/	$ 6,500
Staffing FTE's	5	3

a/ Reflects a general reduction of $30,000; APD Reduction, and a reduction of $631,000 in compliance with the Gramm-Rudman-Hollings Deficit Reduction Act, PL 99-177.

An increase in Transportation and Systems Integration in FY 1987 is also requested. The FY 1987 request of $33.4 million compared to the FY 1986 appropriation of $21.3 million from the Nuclear Waste Fund represents an effort to be initiated during FY 1986 for the private sector to design, fabricate and test prototype casks for DOE to consider in developing transportation casks for shipping spent fuel from reactors directly to a repository or from reactor to an MRS.

The FY 1987 budget request under the Civilian Radioactive Waste R&D program of $6.5 million represents a decrease from the FY 1986 budget of $16.0 million. Essentially, this results from the fact that no funds are being requested for research and development concerning alternatives for permanent disposal of spent fuel and high-level waste. During FY 1986 and previous years, the principal alternative disposal concept funded has been subseabed disposal. Activities related to research and development in alternative disposal concepts called for in Section 222 of the NWPA are not proposed for funding after FY 1986.

NUCLEAR WASTE FUND PROGRAM

With the overview of the FY 1987 budget request in mind, I would like now to give a brief status of the program.

The NWPA calls for DOE to site, design, construct, operate and close the Nation's first geologic repository for spent fuel and high-level waste; to site and design a second repository; to submit a proposal to Congress on the need for and feasibility of Monitored Retrievable Storage facilities; to

develop a transportation system and carry out certain other activities in support of the development of a disposal system. It established a method of disposal, a schedule, technical processes and a funding mechanism -- the Nuclear Waste Fund -- to ensure successful implementation of the NWPA.

Interwoven throughout these activities is the requirement for an extensive system of interactions providing checks and balances to ensure Federal accountability to the States, affected Indian Tribes, the public, the electric utilities, their ratepayers and the Congress. To ensure the accountability of the Federal Government -- specifically, DOE -- to the other parties and concerned citizens, we have on many occasions expanded the interactive process beyond that called for in the NWPA. We have been undertaking steps to ensure that the affected States and Indian Tribes can provide early input to DOE's decisionmaking processes. For example, we have invited affected States and Indian Tribes to participate in the Office of Civilian Radioactive Waste Management internal coordinating group on socioeconomic and environmental issues.

Repositories

To date, DOE has identified nine potentially acceptable sites for the first repository, prepared draft Environmental Assessments which propose five of those sites as suitable for site characterization and propose three of the five sites for recommendation to the President for site characterization.

A lengthy review process was undertaken in which DOE reviewed approximately 23,000 comments received on the draft

Environmental Assessments. Based on comments, we selected one of three ranking methodologies which have been identified in the draft EA's to be used in the decision process to formally recommend sites for characterization. At the suggestion of several commentors, last fall, we requested the National Academy of Sciences (NAS) Board on Radioactive Waste Management to conduct an independent review of the appropriateness of the ranking methodology -- referred to as the utility estimation method.

The NAS Board responded that the methodology, if properly applied, is appropriate, but further recommended that the application of the methodology be reviewed. Therefore, over the last several months, while DOE has been completing final Environmental Assessments to accompany the formal nomination of sites for characterization and applying the ranking methodology in the recommendation decision process, the NAS Board and DOE met several times on this subject. We received their comments in mid-April which indicated their general endorsement of the application of the methodolgy.

We consider the review by the NAS Board to be quite valuable in ensuring us, as well as the public, that the decisions being made in the siting process are indeed scientifically and technically sound.

We currently expect to issue final Environmental Assessments around mid-May at which time formal nominations and recommendations of sites for characterization will be made. The formal nomination and recommendation will be based on siting guidelines

(10 CFR 960), utilizing available geotechnical, environmental and other relevant information. They will be accompanied by Environmental Assessments and the comments provided by the NAS Board and other relevant decision documents.

The FY 1987 budget request for first repository activities is $541.8 million compared to the FY 1986 appropriation of $386.0 million. This increase is primarily due to the site characterization activities which are planned to commence in FY 1987. The extensive site evaluation involved in site characterization includes construction of deep, exploratory shafts at the three sites approved for site characterization and in situ testing. DOE is planning two shafts at each site. Shaft construction at the three sites will take approximately two years with in situ tests scheduled to start in FY 1989.

The FY 1988 budget estimate for first repository activities is $632.4 million and the FY 1989 budget estimate is $571.5 million.

Major program milestones associated with the first repository are:

Milestone	Calendar Year
o Issue final environmental assessments	May 1986
o Nominate at least five sites and recommend three candidate sites to President for characterization	May 1986
o Issue initial Site Characterization Plans (SCP) for tuff and basalt candidate sites	December 1986
o Issue initial SCP for salt candidate site	May 1987
o Begin construction of first exploratory shaft	May 1987
o Issue Final Environmental Impact Statement	1991
o Recommend first repository site to President	1991
o Recommend first repository site to Congress	1991
o Submit construction application to NRC	1991
o Receive from NRC Construction Authorization	1993-1994
o Begin Phase I Operations	1998

As previously mentioned, the NWPA directs DOE to conduct site investigations for a second repository, although construction of the second repository is contingent upon future Congressional authorization. The process for selecting the second repository site is similar to the process for the first repository with decision points approximately-seven-to ten years later than those for the first repository.

For the second repository, DOE may consider sites identified as potentially acceptable but not nominated for the first repository, sites found potentially acceptable from rock formations not previously studied in the first repository

selection process and sites characterized but not chosen for the first repository site.

Rock formations not previously studied in the first repository selection process have been crystalline rock. Following national surveys, DOE identified 235 crystalline rockbodies in 17 States in three regions -- the North Central, the Northeast and the Southeast parts of the country.

In the "regional phase" of investigation, DOE collected and assessed publicly available geologic and environmental data, reviewed these data with the States and prepared Regional Environmental and Geologic Characterization Reports for each of the three Regions. In addition, through workshops and other interactions with the crystalline States, DOE prepared a Region-to-Area Screening Methodology to be used for narrowing down the 235 rockbodies to a small number of areas preferred for further study.

On January 16, 1986, following application of the Screening Methodology to the data contained in the Regional Characterization Reports, we issued for public comment a Draft Area Recommendation Report (ARR). The Draft ARR proposes from among the 235 rockbodies in 17 States, 12 potentially acceptable sites in 7 States. The 7 States, listed in alphabetical order, are: Georgia, Maine, Minnesota, New Hampshire, North Carolina, Virginia and Wisconsin. The Draft ARR also identifies 8 other areas in 4 of the same 7 States as suitable for possible further consideration.

During the public comment period on the Draft ARR, DOE held approximately 80 public briefings and public hearings in 15 States. After review of the oral and written comments received on the Draft ARR, DOE will issue a final ARR, formally identify potentially acceptable sites in crystalline rock and begin the "area phase" activities for those areas determined potentially acceptable sites for the second repository. Area phase activities include on-site investigations to collect and assess geologic, environmental, socioeconomic and transportation data.

The FY 1987 budget request for second repository activities is $78.7 million compared to the FY 1986 budget appropriation of $35.5 million. The increase is principally to fund preparation for on-site area-phase work which is scheduled to begin in FY 1988 and take approximately three-to-five years. The FY 1988 estimate for second repository activities is $74.2 million and the FY 1989 estimate is $71.5 million.

The major milestones leading to the site recommendation for the second repository are as follows:

Milestones	Calendar Year
o Issue final Region-to-Area Screening Methodology	April 1985
o Issue final regional characterization reports	September 1985
o Issue draft Area Recommendation Report (ARR)	January 1986
o Issue final ARR and Identify Potentially Acceptable Sites (July 1986 issuance date has been our objective, but the actual date will depend on the number and nature of comments received on the draft ARR.)	Summer 1986
o Issue final Area Characterization Plan and initiate crystalline rock area phase field investigations	November 1987
o Nominate and recommend sites to President for characterization	1993
o Recommend second repository site to Congress	1999

Monitored Retrievable Storage

The NWPA (Section 141) directs DOE to complete a study of the need for and feasibility of an MRS, and to submit to the Congress a proposal for the construction of one or more MRS facilities. The NWPA specifies that the proposal include a program for siting, development, construction and operation of an MRS facility; site specific designs and cost estimates for the construction of such a facility, should Congress approve its construction; a plan for funding the construction and operation of such a facility; and a plan for integrating such a facility into the overall Federal waste management system.

In spring of 1985, DOE completed its preliminary analysis of the need for and feasibility of an MRS facility and announced our conclusion that such a facility could serve as an integral and

important part of the overall waste disposal system. Over the next few months, a proposal for an MRS facility was prepared; and in mid-December, a review draft of the proposal and supporting documents was sent to the Environmental Protection Agency and the Nuclear Regulatory Commission for comment as specified by the Act. Generally favorable comments have been received from both agencies.

DOE has been enjoined from making any proposal or filing any documents with the Congress which rely on the siting studies performed in conjunction with the proposal preparation process. We have appealed the injunction and are hopeful that we will receive a speedy resolution of the legal issues involved so that we can submit the proposal.

Because of the injunction, I am limited in the extent to which I can describe the elements of the proposal. However, I can give the following details:

In our proposal, we will recommend that Congress:

- Approve the construction of an MRS facility at a specific site;
- Limit the storage capacity at the MRS facility to 15,000 metric tons of spent fuel;
- Preclude waste acceptance by the MRS facility until a construction authorization for the first repository is received from the NRC;
- Direct DOE to implement measures responsive to the concerns and recommendations of the host State and local governments; and,
- Direct DOE to implement the program plan accompanying the proposal.

The proposal will be accompanied by NRC and EPA comments. The proposal contains extensive and unique provisions with regard to State and local involvement in the MRS program. The most innovative and far-reaching element contained in the proposal is the establishment of an MRS Steering Committee to provide a formal mechanism to obtain State and local input, including recommendations and evaluations regarding the design, construction, operation and, eventually, the decommissioning of the MRS facility. This Committee, composed of State and local government representatives of their own choosing, as well as DOE and industry representatives, would provide guidance, conduct evaluations, and, if necessary, recommend corrective actions with regard to the MRS facility. We are proposing that the Committee's involvement extend to a number of areas -- environment, safety and health; transportation; public information; and financial matters.

In accordance with other provisions of the NWPA, should Congress approve proceeding with an MRS facility, we are committed to seeking immediately to enter into a formal Consultation and Cooperation Agreement with the host State.

The FY 1987 budget request supports proceeding with activities that are critical to deployment of an MRS facility. With this in mind, the FY 1987 request for MRS activities is $46 million compared to the FY 1986 budget appropriation of $3 million. These funds would be used primarily for site data collection and analysis, final design of the facility itself, regulatory compliance studies and State liaison activities. The schedule for construction of the MRS allows ten years from the

time Congress approves our proceeding, to the start up of operations. The FY 1988 estimate is $50 million and the FY 1989 estimate is $53 million.

Transportation and Systems Integration

The FY 1987 budget request for activities associated with Transportation and Systems Integration is $33.4 million. The FY 1988 estimate is $33.8 million; and the FY 1989 estimate is $31.0 million.

The funding request for FY 1987 provides for development of adequate transportation and integrated systems for the shipping and management of nuclear waste among the various components of the disposal system.

The FY 1987 major activities include funding for the private sector to design, fabricate and test prototype casks for truck, rail and barge transport based on competitive procurements. Work will be continued to support institutional programs environmental and economic analysis and technology development, data systems and testing and engineering development and systems integration.

The FY 1988 and FY 1989 estimates of $33.8 million and $31.0 million, respectively, would fund the continuation of these efforts.

Program Management and Support

The FY 1987 budget request for program management and technical support is $69.5 million. The FY 1988 estimate is $72.7 million; and the FY 1989 estimate is $72.2 million.

The FY 1987 funding level of $69.5 million provides technical support for waste management activities including (a) technical support integration, (b) development of standard materials characterization methods by the Material Characterization Center, and (c) supporting studies including fund management activities.

This funding level provides for a sustained staffing level from FY 1986 to FY 1987 of 292 full-time equivalent positions at headquarters and in the Operations Offices for fund management, site investigation, technology development and institutional liaison associated with the technical management of the repository, MRS (if approved), supporting programs and the management of the Nuclear Waste Fund.

The FY 1988 and FY 1989 estimates of $72.7 million and $72.2 million, respectively, will provide for program management and technical support associated with site characterization activities at three candidate repository sites, intensified siting efforts in the second repository program, a vigorous MRS program and increasing efforts in transportation systems development. Major emphasis will continue on developing an integrated cost-effective waste disposal system providing full protection of public health and safety and the environment.

Nuclear Waste Fund

In April 1983, DOE adopted a fee of one mill (one-tenth of a cent) per kilowatt hour charged to utilities for all nuclear-generated electricity beginning April 7, 1983, as specified in

the NWPA. Revenues collected from the on-going fee by DOE through December 31, 1985, total approximately $880 million.

In addition to spent fuel generated since April 7, 1983, spent fuel or high-level waste generated prior to that date is subject to a fee equivalent to an average charge of one mill per kilowatt hour. Utilities had until June 1985 to decide on one of three payment options. Those who chose to pay in one lump sum by June 1985, to save interest charges, made payments totalling more than $1.4 billion. This represents more than half of the one-time fee liability of $2.3 billion for civilian nuclear waste in existence prior to April 7, 1983. Following receipt of these monies, DOE reimbursed the U.S. Treasury approximately $265 million, the total amount owed on the appropriated debt transferred to the Nuclear Waste Fund upon enactment of the NWPA.

In April 1985, the President accepted DOE's recommendation to dispose of defense waste in a commercial repository. The Federal Government, therefore, will pay a fee equivalent to that paid by utilities. This use of the repository will generate additional revenue for the Fund. As stated in DOE's March 1986 Nuclear Waste Fund Fee Adequacy: An Assessment, it is assumed at this time that approximately $3.4 billion (in 1985 dollars) will be collected for costs of handling atomic energy defense wastes over the life of the program. This assumption is made based upon review of several alternatives being considered for the calculation of such fees and, therefore, these estimates are not included in the revenue projections below.

The revenue projections based on the one mill per kilowatt hour fee are shown in Table 3.

TABLE 3

NUCLEAR WASTE FUND REVENUE PROJECTIONS
($ in millions)

FY 1983 (actual)	$ 73.6
FY 1984 (actual)	329.5
FY 1985 (actual):	
-One mil/KWh	367.3
-One-time fee	1,427.4
-Interest Earned	38.4
FY 1986	
-One mil/KWh	378.6 a/
-One-time fee	2.3
-Interest Earned	118.0 b/
FY 1987	
-One mil/KWh	420.5 a/
-One-time fee	2.5
-Interest Earned	115.0 b/
FY 1988	
-One mil/KWh	474.5 a/
-One-time fee	17.2
-Interest Earned	105.0 b/
FY 1989	
-One mil/KWh	508.6 a/
-One-time fee	17.5
-Interest Earned	99.0 b/

a/ Based on projected gross nuclear electricity generation reduced by 5% to approximate net nuclear electricity generation as a result of the recent Wisconsin court decision. (Wisconsin Electric Power Company, et al vs. Nodel, 83-1066,84-8571 (decided December 6, 1985)). At the time of this budget submission, net nuclear electricity generation projections were not available.

b/ Based on average yield of Treasury security portfolio.

CIVILIAN RADIOACTIVE WASTE R&D PROGRAM

Development and demonstration activities under the Civilian Radioactive Waste R&D Program are funded from the General Fund rather than funds collected from the utilities and deposited into the Nuclear Waste Fund.

The FY 1987 budget request for the Civilian Radioactive Waste R&D activities is $6.5 million compared to $16.0 million in FY 1986.

I would like to briefly discuss the strategy and highlight the activities which we plan to undertake in FY 1987.

Strategy

DOE's Civilian Radioactive Waste R&D program efforts are to utilize all means directed or available through the Act or other authority to encourage and expedite the availability of licensed new at-reactor storage technologies. No funds are requested for research and development concerning alternative means and technologies for the permanent disposal of high-level radioactive wastes, including the subseabed disposal concept. Activities to implement Section 222 -- alternative means of disposal -- are not proposed after FY 1986.

Spent Fuel Storage R&D

DOE's spent fuel storage development program is intended to encourage and expedite the most efficient use of existing storage facilities and the addition of new, licensed capacity in a timely fashion. The FY 1987 budget request to support these activities is $6.3 million compared to $8.5 in FY 1986.

Activities in FY 1987 will include continued dry storage cask testing as part of a cooperative agreement with Virginia Power; completion of preliminary tests and analyses on a transportable cask as part of a cooperative agreement with Carolina Power and Light; and initiation of rod consolidation demonstrations of spent fuel as part of a cooperative agreement with Northeast Utilities Services Company. In addition, we plan to continue cooperative activities in information exchange regarding spent fuel storage and disposal with non-nuclear weapon states and to continue to participate in international activities with the International Atomic Energy Agency, the Nuclear Energy Agency and the Federal Republic of Germany.

We do not plan to continue investigations into alternative disposal concepts, including subseabed disposal, nor generic methods and support studies beyond those international information exchanges and international involvement discussed under spent fuel storage development.

Program Direction

The FY 1987 budget request for program direction is $.2 million. At this level, three full-time equivalents would be funded to manage the Civilian Radioactive Waste R&D programs. Included are administrative and technical personnel who manage a broad range of activities such as: research, development, demonstration, industrial involvement and international programs.

In summary, Mr. Chairman, the FY 1987 budget request for spending authority under the Nuclear Waste Fund and for

appropriations under the Civilian Radioactive Waste R&D budget are designed to carry out an integrated waste management program in an efficient and effective manner and to achieve the 1998 mandate of the Nuclear Waste Policy Act, that is, to have in place a comprehensive and functional waste disposal system to begin receiving spent fuel.

This concludes my remarks in support of the FY 1987 Nuclear Waste Fund and R&D programs. I shall be pleased to answer your questions at this time.

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The CHAIRMAN. Thank you, very much, Mr. Rusche.

I have a number of questions, but I will limit myself on the first round of questioning so that we can get to others, as well.

In the March report on the adequacy of the nuclear waste fund fee, you make reference for the first time to an actual contribution from defense programs for the disposal of defense wastes in a commercial repository. The figure mentioned is $3.4 billion, which is about 10 percent of the total estimated cost of the program. When will this information be formally proposed?

Mr. RUSCHE. We have a proposed rulemaking that we have agreement on with OMB, and would hope to have that proposed rulemaking issued for public comment later this spring. I apologize for the fact that on two or three other occasions I have said, "I hope to have it available next week." I believe, in fact, that we will have it available for public consideration very shortly.

The CHAIRMAN. Will the public have an opportunity to comment?

Mr. RUSCHE. Yes, indeed. We will propose for public consideration at least three options, one of which is the option that is referred to in the life-cycle cost estimate, a fee adequacy study.

The CHAIRMAN. How will you, in DOE, factor into the proposal these public comments that are received?

Mr. RUSCHE. We will factor them in the same manner that we do the general activities when we engage in public dialog. We will identify three proposals. We will look at the public comments and possibly modify one or more of these proposals and then arrive at a conclusion which would then be formalized.

The CHAIRMAN. Has there been any decision made as to how the defense contributions would be made? That is, an annual contribution, incremental contribution, or a one-time contribution?

Mr. RUSCHE. Our preference will likely show that we favor a mechanism of payment that is very analogous to the utilities' payments; that is, a one-time fee, plus annual payments. We will identify in other options other means, such as deferred payment or one-time payment.

The CHAIRMAN. The Department recently narrowed down its candidates for a second repository to 12 sites in seven States. I notice the DOE's funding request for the second repository for fiscal year 1987 is $79 million, or double what it is this year. Isn't that an awful lot of money to be spending on a program that has not yet been approved by the Congress?

Mr. RUSCHE. Mr. Chairman, whether it is an awful lot of money or not, I perhaps would be better able to tell you what we plan to do with it and you make the judgment as to whether it is an awful lot of money.

Consistent with the schedule required by the act, as modified in our mission plan, which did stretch out the second repository by several years, we proposed that if we continue on the course that we are now on, we would be prepared later this year, or next year—depending on how long it takes us to respond to the comments—to begin field investigations. And it is that large increment that is attached, to begin field investigations.

There has been a good bit of discussion, both by members on this committee and elsewhere as to whether this is the appropriate

time to make such consideration. I would be glad to make such consideration. I would be glad to visit that issue, either now or later.

The CHAIRMAN. How much is planned for fiscal year 1988 and 1989?

Mr. RUSCHE. I think the amounts are about that same amount, as shown.

The CHAIRMAN. A large increase and then are relatively level?

Mr. RUSCHE. For the next 2 or 3 years, yes.

The CHAIRMAN. Well, you more or less volunteered to talk about timing. That happens to be my next question. Is it a good idea to move forward now on that, aggressively, or would it be perhaps be more prudent to accelerate the work in this area later on to allow you to focus your current efforts on the first repository and the MRS, which are both more important and more immediate and have more public attention.

Mr. RUSCHE. Mr. Chairman, we certainly share the view with you that the first repository and MRS deserve our first attention; and I would want you to know that nothing we are doing with respect to the second repository is in any way detracting from that emphasis.

On the other hand, we have received many comments. My latest estimate is that we have received over 60,000 comments on the draft area recommendation report for a second repository, or the crystalline siting program therein.

The Secretary and I have both discussed this matter. I think that we are, of course, charged by the act to take certain actions. We display in the emission plan our proposal to follow those actions which did, in fact, modify the schedule. It is perhaps difficult for me to put myself in place of the Congress and try to guess why Congress took this course. I have some ideas.

But one thing is for sure, I think until we have confidence that we have gotten through some of these other decision steps on the first repository, that it may not be very wise just to abandon consideration of a second repository.

On the other hand, if we get through this decision step, with the President's decision and selecting three sites for characterization for the first repository, and we begin to see some indication that an MRS, which would add a number of features to the system that are very desirable, is more likely, I think it would be time for us to collectively fall back and consider whether the timing for a crystalline repository is as urgent as was thought in the act.

But I think until we get those first two steps pretty well in place, we have a great deal to learn and gain from considering the crystalline project by means of maintaining the availability of alternative sites.

The CHAIRMAN. I guess the reason I asked the question is, maybe in retrospect, we made an arbitrary judgment about timing and as we look at both your progress, with respect to the first repository, and the MRS, and the public reactions to the several steps that are required by the act, maybe we might make haste better if we made it slowly.

Mr. RUSCHE. With respect to this program, I think that is a subject that may well be timely in a month or two.

The CHAIRMAN. Would congressional approval of an MRS facility require amendments to the Nuclear Waste Policy Act?

Mr. RUSCHE. Mr. Chairman, we do not believe so. We see that the approval by Congress of the elements that are in our proposal, or matters related thereto, would be essentially completing action that was prescribed by the act. We think it would be important for Congress to give attention to a number of the specifics that are in our proposal because they do refine and define just how we would proceed.

The CHAIRMAN. Within the $46 million requested under MRS in the budget, will any site construction work take place?

Mr. RUSCHE. No, sir.

The CHAIRMAN. According to your reading of the Nuclear Waste Policy Act, when does a State have the opportunity to formally disapprove the siting of an MRS within its borders?

Mr. RUSCHE. We would think at the time that the matter is before Congress, such as is now. In fact, our interactions with the State over the last year or year and a half have been for that very purpose, and if we are allowed to send a formal proposal, we have received comments from the State of Tennessee, and I believe you have separately received such comments indicating the State's view.

The CHAIRMAN. Are there any other potential sites for MRS, other than those under current consideration, that DOE could consider that would impart the same basic advantages to the Nuclear Waste Program?

Mr. RUSCHE. We considered a number of sites in our siting document, and I think in view of the injunction which focuses attention on that document itself, I prefer to defer specific consideration, but would note that the value of MRS, we think, attaches largely to its central location and we have identified a number of other sites as possibilities.

The CHAIRMAN. The court decision in the Nevada lawsuit basically says that subject to certain limitations, States are eligible for funding of independent presite characterization activities. What are the certain limitations of this eligibility?

Mr. RUSCHE. Mr. Chairman, they have to do with appropriateness, technical adequacy, noninterference, and in some instances, the determination and making the case that conducting the research at this particular moment, as opposed to some later time in the program, is essential for the State to be able to exercise its disapproval rights later on.

We have embodied those in a set of internal guidelines, which are available to the States and to the public. I would be glad to furnish you a copy of those.

The CHAIRMAN. If you would do so, please.

Mr. RUSCHE. We would be glad to.

[The information follows:]

DOE F 1325.8
(7-79)

U.S. DEPARTMENT OF ENERGY

memorandum

DATE FEB 04 1986

REPLY TO ATTN OF RW-25

SUBJECT Implications of Nevada Lawsuit Decision

TO T. Clark, NV
M. Lawrence, RL
H. Rauch, CH

On December 2, 1985, the Court of Appeals for the Ninth Circuit issued its decision in State of Nevada v. Herrington, (No. 84-7846). The Department will not appeal this decision. At issue was whether DOE was required, under the grant provisions of the NWPA, to fund States/Indian Tribes to conduct pre-site characterization studies involving independent primary data collection. The court ruled that such studies must be funded if they "would be essential to an informed statement of reasons explaining why [the State/Indian Tribe, if on Tribal land] disapproved the recommended repository sites," and if the ability of the studies to contribute to the statement of reasons "depends on their being initiated prior to site characterization."

In reviewing grant applications and implementing this decision, the following procedures shall be applied:

1. Identify any activities described in a State/Indian Tribe's grant application that constitute pre-site characterization studies involving the collection of independent primary data, i.e., activities or studies, the purpose of which is the generation of data, rather than the review or analysis of existing data.

2. Determine if the State/Indian Tribe justifies such studies as essential to the development by the State/Indian Tribe of an informed statement of reasons supporting a State's/Indian Tribe's disapproval of a recommended site under Section 116(b) or 118(a) of the NWPA. The State/Indian Tribe justification should focus specifically on the nature of the activities in question, not on the timing of the studies (which is the issue identified in #3 below). The issue will be whether the conclusions reached as a result of the proposed activities could contribute to a State/Indian Tribe conclusion that the site is unacceptable, i.e., unacceptable from the standpoint of the reasons a State/Indian Tribe would disapprove a site, and that such demonstration is dependent upon the data to be generated by the proposed activities.

3. Determine if the State/Indian Tribe has shown that the contribution of the studies to the informed statement of reasons depends on their being initiated prior to site characterization. This showing should be presented in the context of the

Department's timing of the site characterization program and recommendation decision. To be funded, it must be found that unless the studies are initiated prior to site characterization, the results of those studies will not be available for consideration by the State/Indian Tribe at the time it must formulate its informed statement of reasons for disapproval.

4. Determine if the proposed studies are reasonable, i.e., scientifically justifiable (recognized study or test methods are to be employed and that the methods are capable of yielding the expected data or results), and proposed to be performed by demonstrably competent contractors (the proposed contractors have adequate experience in the field, including an adequate quality assurance program to ensure that the data are reliable).

5. Determine if the proposed activities would unreasonably interfere with or delay the Department's own activities. This includes consideration of any potentially adverse impact on the site.

The court further ruled that certain provisions of the OCRWM Phase III financial guidelines are unduly restrictive. Specifically, the court ruled that two clauses in the Phase III guidelines are unlawful, "duplication of data collection efforts and associated activities should be minimized to the maximum extent practicable and avoided if at all possible," and that [States and Indian Tribes] may "receive funding to run independent tests on DOE data, where the need for such independent testing can be justified." Consequently, the sentences containing these provisions in Section 5.4, Phase III, of the September 1984 financial assistance guidelines are no longer operative.

Until further notice, Section 5.4, without the two sentences noted above, shall be followed, and in addition the following procedures shall be applied in determining grant eligibility of proposed studies involving independent data collection during site characterization:

1. Identify any activities described in a State/Indian Tribe's grant application that constitutes site characterization studies involving the collection of independent primary data, i.e., activities or studies, the purpose of which is the generation of data, rather than the review or analysis of existing data.

2. Determine if any such proposed studies are reasonable, i.e., scientifically justifiable (recognized study or test methods are to be employed and that the methods are capable of yielding the expected data or results), and proposed to be performed by demonstrably competent contractors (the proposed contractors have adequate experience in the field and an adequate quality assurance program to ensure that the data are reliable).

3. Determine if any such proposed activities would unreasonably interfere with or delay the Department's own activities. This includes consideration of any potentially adverse impact on the site.

4. In addition, Section 116(c)(1)(B) and Section 118(b)(2)(A) of the NWPA provides that grants may be provided to States and affected Indian Tribes only for the purpose of enabling such State or affected Indian Tribe--

(i) to review activities taken under this subtitle with respect to such site for purposes of determining any potential economic, social, public health and safety, and environmental impacts of such repository on the State and its residents;
(ii) to develop a request for impact assistance under paragraph (2);
(iii) to engage in any monitoring, testing, or evaluation activities with respect to site characterization programs with regard to such site;
(iv) to provide information to its residents regarding any activities of such State, the Secretary, or the Commission with respect to such site; and
(v) to request information from, and make comments and recommendations to, the Secretary regarding any activities taken under this subtitle with respect to such site.

OCRWM is currently revising the financial assistance guidelines in accordance with the court's ruling and the revised guidelines will be sent for your review shortly. The above procedures are to be followed on an interim basis until the revised guidelines are issued.

As you know, existing guidance prohibits use of NWPA grant funds for the purpose of funding litigation against the Department. The Ninth Circuit decision does not affect this prohibition.

Ben C. Rusche

Ben C. Rusche, Director
Office of Civilian Radioactive
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cc: R. Bauer, RW-10
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INTERNAL GENERAL GUIDELINES FOR IMPLEMENTING FINANCIAL ASSISTANCE (GRANTS) FOR REPOSITORY PROGRAMS UNDER SECTIONS 116 AND 118 OF THE NUCLEAR WASTE POLICY ACT OF 1982 REVISED SEPTEMBER 7, 1984

1.0 PURPOSE

The purpose of the financial assistance program under the Nuclear Waste Policy Act of 1982 (the Act) is to ensure that eligible States and affected Indian Tribes have sufficient financial resources to participate in the repository development process as mandated by the Act. DOE is fully committed to the objective of timely and effective State and tribal participation and will use the financial assistance provisions of the Act to assist States and tribes in meeting this goal.

These are general guidelines. Because the needs and plans of the States and tribes involved in the different projects may vary substantially, individual DOE Project Offices will be required to deal with individual requests on a case-by-case basis. The purpose of the general guidance provided here is to assist DOE Project Offices by:

- establishing a single framework within which DOE field offices can respond to requests and negotiate and award grants;
- ensuring that all States and Indian tribes involved in the process are treated as equitably as possible; and
- ensuring that activities funded by the grants are consistent with the Act.

The purpose of these guidelines is to assist DOE in awarding grants to States and tribes in the several phases of the repository development process.

2.0 BACKGROUND

The financial assistance provisions of the Act relating to repository development are contained in Sections 116 and 118. Section 116 contains provisions applicable to the States and Section 118 contains similar provisions applicable to affected Indian tribes.

For purposes of this guidance, the repository development process has been divided into four phases: (I) prenotification; (II) notification/ nomination; (III) characterization; and (IV) construction.

Phase I — States or tribes that have not been formally notified by DOE as having "potentially acceptable" sites but in which exploratory/ screening work is taking place. The Department has determined that grants may be awarded to these States or tribes prior to the time they have been notified as having potentially acceptable sites. These are referred to as "prenotification" or Phase I States or tribes and are the States/tribes that may at some future date contain a potentially acceptable site for the second repository. The 17 crystalline States fall within this category.

Phase II — States or affected tribes that have been notified under Section 116(a) of the Act that they have "potentially acceptable site" or sites for a repository. These are referred to as "notification" or Phase II States or tribes. States/tribes currently (June 1983) eligible for Phase II grants are Washington, Nevada, Utah, Texas, Louisiana, Mississippi, the Yakima Indian Nation, and the Umatilla Indian tribe. Sections 116(c)(1)(A) and 118(b)(1) of the Act provide for grants to States or tribes in this phase.

Phase III — States or affected tribes with recommended candidate sites that have been approved for site characterization by the President. These are referred to as "characterization" or Phase III States or tribes. Sections 116(c)(1)(b), 116(c)(3), 118(b)(4), and 118(b)(2)(A) of the Act specify the activities for which States and affected tribes may receive grants from DOE in this phase.

Phase IV — States or affected tribes with a site that has been authorized by the NRC for construction of a repository. These are referred to as "construction" or Phase IV States or tribes. This category will include only the sites ultimately selected for repositories. Sections 116(c)(2)(A), 116(c)(3), 118(b)(4), and 118(b)(3)(A) specify the activities for which States and affected tribes may receive grants from DOE in this phase.

This present set of guidelines focuses on financial assistance available during Phases I, II, and III. States and Indian tribes are eligible for new grants as sites proceed from Phase I through Phase IV. There should be no lapse in funding as States and Indian tribes progress from one phase to the next. However, DOE must discontinue funding for sites that are not selected for the next phase, i.e., are eliminated as candidate sites during any phase. Guidelines for terminating grants are provided later in this guidance.

3.0 ELIGIBILITY FOR GRANTS

States and affected Indian tribes that have been notified pursuant to Section 115(a) are eligible to receive financial assistance under the Act and fit into Phase II of the financial assistance program. States and affected Indian tribes are eligible for Phase III grants where a candidate site for a repository is approved under Section 112(c) for site characterization. DOE has also determined that where the Department is conducting exploratory/screening activities prior to notification, pursuant to Section 116(a), States and tribes may be eligible for grants for a limited range of activities related to State/tribe review of and comment on DOE documents and plans and other related activities.

4.0 RECIPIENTS OF GRANTS

4.1 Indian Tribes

The Act identifies an affected Indian tribe as the appropriate recipient of grants awarded under Section 118(b).

4.2 States

Groups within a State that could be potential grant recipients include:

1. The Governor's office or an office under the Governor - either an existing department, an advisory board or a new agency dealing exclusively with the nuclear waste issue;

2. An office or board of the State legislature; and

3. A local governmental entity such as a county government office.

The Department intends to negotiate and award grants to a single entity within the State (as determined by the State) while recognizing the legitimate needs of various parties within the State for financial support.

5.0 ACTIVITIES FUNDED

5.1 General

The Act provides basic guidance on allowable project activities for which grants may be awarded. These allowable uses will vary depending on the phase of the repository development process in which the States or affected tribes are involved. Activities funded will also vary with the level of participation desired by the State or tribe.

Grant applications should contain a detailed description of activities planned by the State or Indian tribe for the term of the grant and a budget that details the costs of conducting those activities.

DOE's Financial Assistance Rules, 10 CFR Part 600 (47 FR 44076, October 5, 1982), establish minimum requirements applicable to all grantees for reporting on progress and expenditures of grant funds.

5.2 Phase I (Prenotification) States or Tribes

- Review and Comment - Activities in this category should focus on reviewing and providing comment on DOE documents and plans related to repository development activities within the State or tribal area. Examples of such documents and plans include:

  - Mission Plan;
  - Siting Guidelines;
  - Regional Characterization Reports;
  - Region-to-Area Screening Methodology;
  - Area Recommendation Reports; and
  - Area Characterization Plan.

- Attendance at DOE-Sponsored Meetings and Workshops

- Preparation for C&C Agreements - Funds may be provided to permit the State or tribe to prepare to negotiate a C&C agreement. Activities may include information gathering, developing draft provisions, and initiation of training of staff in preparation for negotiations with DOE. (See DOE Internal General Guidelines for Implementing the Consultation and Cooperation Agreement Provisions of Section 117 of the Nuclear Waste Policy Act of 1982). Since C&C negotiations, pursuant to Section 117(c), are to be initiated only after potentially acceptable sites have been identified, funding for this type of activity should be limited to those States and tribes where DOE has made a preliminary identification that a potentially acceptable site may be located (e.g., in a draft Area Recommendation Report).

- Public Information Programs and Provisions of Information to Officials - Activities in this category should focus on:

  - Dissemination of program information to various State, local, and tribal officials and the public;

  - Coordination with interested groups within the State or tribe, including other State agencies with an interest, the legislature, local governments, and citizen groups;

- Preparation and participation in public briefings and meetings, including preparation of briefing materials; and

- Participation in regional interstate information meetings as appropriate.

Due to the preliminary nature of DOE's technical program at the Phase I stage, development of new publication materials should be kept to a minimum and coordinated between the grantee and DOE.

5.3 Phase II (Notification) States or Tribes

Activities that may be funded by Phase II grants are specified in Sections 116(c)(1)(A) and 118(b)(1) of the Act. The grants shall be made "for the purpose of participating in activities required by Sections 116 and 117 or authorized by written agreement under Section 117(c)." This provision covers a broad range of activities that may be eligible for funding. Special consideration should be given to activities designed to achieve the goals of maximizing State or tribe involvement in the overall repository development program and enabling States and tribes to participate effectively in the development of binding written C&C agreements. Examples of permissible activities include the following:

- Activities Leading to C&C Agreements - DOE is required to begin negotiations on the C&C agreements within 60 days after (1) a candidate site has been approved for characterization by the President, or (2) receipt of a written request by a State or Indian tribe notified under Section 116(a), whichever occurs first. A State or tribe may wish to gather information, develop draft provisions, orient and train staff for the negotiation of C&C agreements, and conduct C&C negotiations.

- Review and Comment - Activities in this category should focus on reviewing and providing comment to DOE on the plans, reports, proposed rules, etc., that are relevant to repository development activities within the State or tribal area. Examples of such items include:

  - Review of documents prepared by or for DOE, NRC and EPA and any other Federal agencies identified in the NWPA. These documents include but are not limited to:

    - Siting guidelines and modifications thereto;

    - Mission Plan;

- Environmental assessments;
- Site Characterization Plan preparation material;
- Geologic/hydrologic evaluation reports;
- Repository engineering reports; and
- Socioeconomic, environmental, and transportation reports.

- Attendance at DOE-Sponsored and Other Program-Related Meetings and Workshops

- Public Information Function - Activities in this category should focus on grantee programs to disseminate information to groups within the State or tribe and respond to questions from individuals or groups within the State or tribal area. DOE may provide parallel services to the public and will coordinate public information activities with the grantee. Activities may include:

  - Development of publication materials;
  - Dissemination of program information;
  - Operation of public information offices;
  - Conducting of public information meetings;
  - Provision of information to officials;
  - Site visits;
  - Participation in and attendance at interstate information meetings as appropriate; and
  - Attendance at project-related meetings.

- Coordination Activities - These activities should enable grantees to coordinate with interested groups and citizens within the State or tribe. These groups might include other State agencies with an interest, the legislature, local governments, and citizens groups. The grantee should assume responsibility for soliciting views of such groups and keeping them informed of State/tribe activities.

- Monitoring, Analyses, and Studies - Activities in this category should focus on the analyses and studies necessary to provide appropriate monitoring and evaluation of DOE activities. Examples of such monitoring may include:

  - Independent review of DOE procedures, analyses, and programs;

  - Participation in technical review of DOE programs; and

  - Participation in development of DOE technical work plans.

5.4 Phase III (Site Characterization) States or Tribes

Activities that may be funded by Phase III grants are specified in Sections 116(c)(1)(B) and 118(b)(2) of the Act. Grants shall be made to States and Indian tribes where "a candidate site for a repository is approved under Section 112(c)." The provisions of the Act pertaining to site characterization cover a broad range of activities that may be eligible for funding, including developing the capability to monitor DOE activities, to understand the technical aspects of the program and its implications, and to evaluate potential impacts. However, duplication of data collection efforts and associated activities should be minimized to the maximum extent practicable and avoided if at all possible. Examples of permissible activities include the following:

- Activities Leading to C&C Agreements - As mentioned in Section 5.3 of the Guidelines, within 60 days of approval of a candidate site for characterization, DOE is required to initiate negotiations toward a C&C Agreement. A State or tribe may use grant funds to gather information, develop draft provisions, orient and train staff for the negotiation of a C&C Agreement and conduct C&C negotiations.

- Review and Comment - Activities in this category should focus on reviewing and providing comment on site characterization activities conducted by DOE, NRC, EPA, and other agencies for the purposes of determining any potential economic, social, public health and safety, and environmental impacts a repository may have on States, tribes and their residents. Examples of such items include:

  - Review of documents prepared by or for DOE, NRC and EPA such as DOE Site Characterization Plans;

  - Testing of DOE computer models; and

  - Review of Quality Assurance audits.

- Attendance at DOE-Sponsored Meetings and Workshops

- Monitoring, Analyses, and Studies - Phase III activities in this category should focus on the monitoring and evaluation of DOE site characterization activities. The grantee may also receive funding to run independent tests on DOE data, where the need for such independent testing can be justified. Examples of activities in this category include:

  - Monitoring of field activities by on-site resident observers;

  - Periodic inspections of DOE operations at site;

  - Monitoring and assessing the technical quality of DOE air or water quality monitoring installations;

  - Monitoring of cultural and environmental information gathering; and

  - Independent laboratory tests with DOE-provided samples, where the need for such testing can be justified.

- Impact Mitigation Request - Development of a request for impact assistance under Phase IV of the financial assistance program is required under Sections 116(c)(2) and 118(b)(3). Such impact assistance should be designed to mitigate the impact of the development of a repository, following the initiation of construction. In order to receive impact mitigation assistance in Phase IV, a State or tribe must prepare and submit "a report on any economic, social, public health and safety, and environmental impacts that are likely as a result of the development of a repository at a site..." This report must be submitted following completion of site characterization. Examples of activities under this category include:

  - Preparation of draft impact report including evaluation of baseline and project-related activities and effects;

  - Establishment of a framework for community participation (e.g., establishment of working groups that would include local citizens, officials, and interest group representatives); and

  - Training for negotiation of binding written agreements concerning impact mitigation at the appropriate time.

- Public Information Programs - Activities in this category should focus on grantee programs providing information to its residents regarding any activities of the State, Indian tribe, the Secretary, or the Commission with respect to a site being characterized, including activities such as:

  - Development of publication materials;
  - Dissemination of program information;
  - Operation of public information offices;
  - Conducting public information meetings;
  - Provision of information to officials;
  - Site visits;
  - Participation in and attendance at interstate information meetings as appropriate; and
  - Attendance at project-related meetings.

5.5 Grants-In-Lieu-Of-Taxes

Sections 116(c)(3) and 118(b)(4) of the Act provide for grants-in-lieu-of-taxes (GILOT) to States, units of general local government and affected Indian tribes during Phases III and IV as defined above. Separate guidelines will be developed to assist in implementation of the GILOT program.

6.0 REVIEW, NEGOTIATION AND FUNDING LEVELS

The DOE Project Offices have the responsibility to review each grant application to determine whether it conforms to the DOE Financial Assistance Rules, the requirements and goals of the Act, and these general guidelines.

The Project Offices working through their respective field operations offices have the authority to negotiate with the grant applicant any changes required to make the grant application conform to the requirements referenced above and the funding available within the project. The Project Office should discuss these requirements with potential grant applicants as early as possible (where possible, prior to receiving a formal application) to keep delays to a minimum in meeting State and tribal financial needs.

The funding levels for various grants should represent a balance between the varying needs of the different States and tribes and the need for equity among the States and tribes. Communication between field offices and Headquarters is essential in developing reasoned judgments on the optimum relationship between a grantee's proposed activities and the level of support requested. No grant shall be approved without Headquarters concurrence.

7.0 LIMITATIONS AND DISCONTINUATION OF FINANCIAL ASSISTANCE

Because of the changing status of States and tribes relative to the geologic repository program under the Act (e.g., a State or tribe can move successively from the Phase I category to Phase IV or can be disqualified from further consideration), each grant should specify the conditions under which continuation awards would be made or denied.

Sections 116(c)(4) and 118(c)(5) specify criteria for termination of the grants under certain circumstances. These criteria refer primarily to termination of site characterization activities by DOE or formal disapproval of a site by Congress or the NRC. A number of sites will be dropped from consideration for a repository long before the termination conditions provided in the Act are reached. To assure that grants are phased out on an orderly basis, each grant should contain terms that specify how funding will be terminated. The following approach is suggested for sites that may be eliminated during Phase I or II:

- Funding would terminate as set forth in applicable OMB Circulars and DOE's Financial Assistance Rules. If standard practices would not adequately protect the interests of the Government, a 90/180 day procedure will be used. Funding would terminate either 90 or 180 days after it has been decided to eliminate a site from further consideration and the State or tribe has been so notified. Generally, the 90 day period should be adequate to permit an orderly discontinuation of funded activities for States or tribes eliminated during Phase I and 180 days should be adequate for States or tribes eliminated during Phase II.

7.1 Unallowable Costs

The Act specifies that no "ordinarily incurred salary or travel expense" is eligible for funding under Sections 116(c)(1)(A) or 118(b)(1). This means that DOE may finance extraordinary travel and salary expenses incurred as a direct result of the provision of services to, or incurred as a direct result of participation in, waste disposal activities of the DOE under the Act. Salary and travel-related expenses of State employees working full- or part-time on waste disposal activities, consultants and other providers of contract services are potentially fundable. However, only those salary and travel expenses incurred by the State or

tribe that would not have otherwise been incurred but for passage of the Act may be considered extraordinary expenses. Only extraordinary expenses, as described above, may be financed for Phase I States/tribes.

8.0 COORDINATION OF GRANT REQUESTS AND AWARDS

The timely exchange of information between the Project Offices and Headquarters and among the Project Offices is necessary to ensure that timely guidance on various specific and general issues is provided when needed, and that reasonable consistency and equity among States and tribes associated with different projects is maintained. To facilitate this exchange of information the Headquarters staff will serve the role of an "information clearinghouse" for grant applications and awards.

The Project Offices shall provide Headquarters staff information copies of all grant applications as they are received. This shall be followed up with informal status reports on negotiations as they proceed. During this process, Headquarters staff will provide guidance to the Project Office as requested and information on how similar situations or applications have been or are being handled in other Project Offices. The Project Office shall also provide to Headquarters copies of all grant awards, quarterly activity reports, and financial status reports. This information will serve as the basis for: (1) a periodic summary report on the level and substance of grant activities under the Act, and (2) providing additional specific guidance.

The CHAIRMAN. Now, you made reference in your summary to the fact that DOE has zeroed the budget for alternative disposal technologies in its fiscal year 1987 budget request. You referred to the subseabed proposal, in particular.

Section 222 of the Nuclear Waste Policy Act requires DOE to continue and accelerate a program of alternative disposal technologies. It doesn't identify one technology; it is multiple.

How can you justify termination of the program at this time?

Mr. RUSCHE. Mr. Chairman, we cannot terminate the program at this time. What we have done in fiscal year 1986 is take steps under the presumption that our proposal for no funding in 1987 is accepted by the Congress. The steps that we are taking in 1986 are to put the program in the best possible mode to either proceed with the program or to accommodate the no further funding.

So, I would like to note that, although we have indicated we do not propose funding beyond 1987, that is not a unilateral choice that we can make. We fully recognize that it is your choice to make in that regard.

But it seems to me that as a prudent manager, if there is a prospect for discontinuing our participation, we should use the existing funds to put the program in the best possible shape to exercise which ever option occurs.

If we did not do that, I feel that we would find ourselves at the end of fiscal year 1986 with a large amount of data and incomplete work which we would end up having to essentially drop in midstream, if our proposal was accepted.

The CHAIRMAN. What you are suggesting is, you put it in good form, put in the library and on the shelves so somebody can look at it in the future. But if I understand you correctly, you are not representing that the research is completed or we know all we need to know.

Mr. RUSCHE. Absolutely. In fact, we have in our statement, and we say we think it merits research, but under the budget stringencies and priorities that we feel necessary to exercise, it is just not something that we can proceed with in the immediate future.

I would note, if I may by way of injection, that friends in the United Kingdom have likewise taken a course somewhat of the same sort. That is, to get the material together, analyze it, put it in form for continued work if and when they decide to proceed.

The CHAIRMAN. Thank you. My time is up.

Senator Johnston.

Senator JOHNSTON. Thank you, Mr. Chairman. Mr. Rusche, you have referred to the geologic repository as a first priority and the MRS as the second priority. I would suggest to you that at the time the bill was passed, and throughout its legislative history, the two technologies have been referred to as parallel path. One is not prioritized over the other and I make that point because I don't want to MRS slipped.

It is quite true and quite clear that the repository is not to be abandoned in favor of the MRS, but at the same time, it is a parallel track—not that I find less enthusiasm on your part for MRS—but the statement of the second priority, I think, is inconsistent with the act.

Mr. RUSCHE. Could I offer just one comment, sir?

Senator JOHNSTON. Yes.

Mr. RUSCHE. We have tried to be very sensitive to the literal fact that it is not authorized and, therefore, did not feel comfortable in assigning presumptively a priority such as you suggest. I can assure you that if the Congress takes action to allow us to proceed with MRS, it will indeed be a parallel priority. In fact, in time, it will be the earlier action to come to completion.

Senator JOHNSTON. When should Congress take that action?

Mr. RUSCHE. A number of benefits that we think attach to MRS are dependent to some extent on getting the MRS in operation as early as we can. Licensing benefits, the ability to deal with the transportation situation more effectively, to accelerate the receipt rate and so forth.

A number of the features are not quite so dependent on timing, but I think the short answer is, as soon as the Congress can act, we think, would be the best course for the system to follow.

Senator JOHNSTON. So that when permitted, you will request authorization this year?

Mr. RUSCHE. Indeed we have, by virtue of the funding that we have requested and all of the conversation that we have had. The formal proposal stands ready the moment the court will allow us to act.

Senator JOHNSTON. Your request will then be in shape to have an authorization in the appropriation act, and that will be your request?

Mr. RUSCHE. Yes, sir. Indeed.

Senator JOHNSTON. Very good. Well, I am glad to hear that.

Mr. RUSCHE. We are ready to go.

Senator JOHNSTON. Excellent. The benefit package for Oak Ridge has not been—the so-called incentive package of things that will almost necessary to be done but have not been fully delineated and described—would not this be a good time to be doing that while we are waiting to fund construction of the MRS?

Mr. RUSCHE. Mr. Chairman, I believe under the terms of the injunction, we are enjoined from discussing with you and taking actions that depend on that specific site consideration. Therefore, we have honored that injunction.

I would note, however, in the proposal for funding for 1987, there is an allowance, I believe, of about $21 million out of that $46 million, which would be for such institutional and State-related purposes.

Senator JOHNSTON. For example, you are going to have to build the casks, manufacture them. They would be built in Oak Ridge, or at the site——

Mr. RUSCHE. At whatever site.

Senator JOHNSTON. And you can identify that fairly well, as to size and cost and number of employees, and that sort of thing, can you not?

Mr. RUSCHE. We could indeed, but we do not have funding at the moment to be doing any of that work. If you will recall, last year, when I had some discussion with both you and Members of the House, we reached a formal agreement that we would refrain from taking anticipatory actions and, therefore, the amount of funding available in fiscal year 1986, which is about $3.5 million, is not suf-

ficient to allow us to take any of those steps, absent further congressional action.

Senator JOHNSTON. What is the status of that lawsuit? I know it is on appeal.

Mr. RUSCHE. It is on appeal to the sixth circuit. We have filed our formal brief, and I believe the State is scheduled for next week to file its respondent brief, and then it is before the court.

Senator JOHNSTON. It seems a rather bizarre decision to say that the executive department cannot communicate with the Congress by sending up that which the law requires you to send up. Was this a one-judge court?

Mr. RUSCHE. I believe the decision was issued by the District Court of Eastern Tennessee, and it is that decision which is on appeal. I believe there is a three-judge panel in the circuit court which is hearing the appeal.

Senator JOHNSTON. How much would it cost to have a second repository?

Mr. RUSCHE. The estimate in the total life cycle cost estimate, which is our basis for making the total aggregated cost, is on the order of $6 to $10 billion, depending on which medium we ended up using.

Senator JOHNSTON. With the MRS, you say it would take 10 years from the time you first—from this year, I guess.

Mr. RUSCHE. From approval to proceed, yes.

Senator JOHNSTON. Now, how much of that is taken up with construction?

Mr. RUSCHE. About 4 years, I believe; 3½ to 4 years.

Senator JOHNSTON. Is that the first 4 years you construct?

Mr. RUSCHE. No, it is the latter 4 years. The earlier years are given over to finalizing design, preparing for the licensing exercise and going through the licensing exercise to receive the construction authorization.

Senator JOHNSTON. I think that is all I have, Mr. Chairman.

The CHAIRMAN. Thank you, very much.

Senator Evans.

Senator EVANS. Thank you, Mr. Chairman. Let me first start off on trying to get a little better understanding of the budget and just how it is going to work in the sufficiency of the Nuclear Waste Fund.

In your written testimony, you have a request for fiscal 1987 of about $770 million, with income of $538 million. That is about a $238 million shortage, which I presume is met by drawing down on the one-time fund. Is that correct?

Mr. RUSCHE. That is correct, sir.

Senator EVANS. That one-time fund, as I understand, was about $1.4 billion, from another table in your testimony. This represents about an 18 percent draw down during the year, and yet you show only a $3 million reduction in interest income. Those two do not seem to work together.

Mr. RUSCHE. I think the amount of interest income on the account is of the order of $18 to $20 million a year.

Senator EVANS. On this chart, it is $118 for 1986.

Mr. RUSCHE. Yes. State your question, again, please.

Senator EVANS. I am presuming that interest income is on the one-time fee.

Mr. RUSCHE. It is indeed.

Senator EVANS. During the year, you are going to reduce that by almost 18 percent, but your interest income is only going down about 2 percent. That does not seem to correlate.

Mr. RUSCHE. I think they do, but I would appreciate if I could give you a more specific answer in writing.

[The information follows:]

Our cash flow analysis for FY 1987 indicates that outlays will be significantly higher at the end of the year than near the beginning. In addition, a large fee payment is expected early in the year. These factors result in a smaller fund drawdown early in the year, thereby resulting in a smaller decline in interest earnings than would be suggested by a comparison of beginning and ending fund balances.

Senator EVANS. I would appreciate that, and in addition, I presume that you are measuring this, as you say, on the average yield of Treasury security portfolio. Presumably, that is one that is consistent throughout Government as specified by OMB during the budget-making process. Is that correct?

Mr. RUSCHE. I believe we have a little more latitude in that we are free to invest in Government securities with an investment strategy, so we may have an opportunity to do better.

Senator EVANS. But your estimate of the future is, is that estimate one of, interest earnings, one that you made based on your estimates of Treasury yields or on OMB's?

Mr. RUSCHE. I believe it is our estimate, based on our strategy using OMB future yields.

Senator EVANS. OK. Then in your written testimony, you might also state what you think will happen as a result of a rather substantial lowering of yields between the time OMB made their estimates and today.

Mr. RUSCHE. We will be glad to advise.

[The information follows:]

The immediate effect of the fall in interest rate yields is that the market value of the waste fund investments rises. Over the longer term, the rate of interest earned on the portfolio will be lower.

Senator EVANS. All right. On the MRS, do you have an estimate of timing as to how long the appeal might take and when you might get some definitive answer? Is there any measure of that at all?

Mr. RUSCHE. I don't think we have a basis for measurement. The courts act in their own time. I think experience would suggest that certainly not within the next 2 or 3 months; maybe within some period not much longer than that, but I think it is a pure guess on our part.

Senator EVANS. Do I understand correctly that the essence of the lawsuit was that the State of Tennessee was insufficiently consulted with during the course of the analysis?

Mr. RUSCHE. I think it went more specifically to the point that the siting procedure that we went through did not involve the State early enough. I think the decision by the court effectively noted that after we made the choices that we made, that we took the very course the court would suggest we ought to have taken to start with. We did not follow the formality of the procedure that

applies to the repository siting program because we believed it was not appropriate.

I think it is much less a question of performance than it is a question of formality.

Senator EVANS. If we are going to get stuck on this kind of formality, is it appropriate to consider some kind of new legislation to speed up the process?

Mr. RUSCHE. I think that if you look at the act, there are certainly—in this section, that is section 141, as well as other sections—there are still areas that are subject to interpretation, that are not crystal clear.

But my view today, as it has been every time we have talked, is that attempts to clarify that would have a much higher probability of obfuscating the issue than they would of clarifying it.

Senator EVANS. In your statement on page 14, you talk about your proposal that you will recommend to Congress on the MRS, and the third one says, "preclude waste acceptance by the MRS facility under a construction authorization for the first repository is received from the NRC. '

I join with Senator Johnston in believing that we ought to move in parallel, that we ought to be as prepared as we can for whatever contingencies may arise, and should we lay that kind of specific requirement on an MRS if, for whatever reasons, we get to a point where we are proceeding in parallel, where the MRS is close to ready to go and we cannot get construction authorization for any one of the first repositories? Then, are you not putting an undo burden on us?

Mr. RUSCHE. I think it is a question of judgment on our part as to how to weigh the value of getting confidence to the country and to the local community, that we were serious, that the repository was the first priority and the objective of the act, and the very concern that you raise.

Our view was that it would be best to take the course we propose and if we face the circumstance that you suggest in 1995 or 1996, that there would be ample time for Congress to reconsider that view.

I think if we took the other course, we would have a hard time convincing many members of the public, many Members of the House that we were not at this point substituting MRS for a repository.

Senator EVANS. Well, I must say that it seems to me that that is not parallelism; that is a definite priority setting in what, really, I think is an unnecessary requirement. It keeps us from operating in parallel.

Mr. RUSCHE. Senator, we certainly would not presume to think that you, if in your judgment, concluded that was the case, would not modify approval conditions so that we would proceed just as you thought appropriate. We believe, based on our discussions with the State and with the local community that this provision would be viewed by many as a very important inclusion, however.

I don't think it suffers quite the problem that you suggest in that if you can proceed without today, I don't see why the Congress couldn't address that question equally promptly in 1995 if it turned out to be the appropriate course.

We would certainly not find it affecting the schedule and the dedication to proceeding on schedule in parallel as you and Senator Johnston both have referred to.

Senator EVANS. I guess my concern is that many of these requirements are being pushed, I am sure, by the various States who are involved, and I am afraid with that kind of finger-pointing, it is going to force every single State in the country to object as strenuously and as loudly as they can over any involvement in any aspect of nuclear waste disposal, and we will get ourselves in a trap that we may not be able to get out of.

Mr. RUSCHE. Well, I can assure you that if I felt that by taking some different course than this one we could avoid the problem you have just described, I would advocate it in a moment.

Senator EVANS. Yes.

Mr. RUSCHE. The circumstance you described is operative today. I don't think this will change that.

Senator EVANS. Maybe not totally operative today in terms of intensity, but you could certainly understanding the intensity of some States that are so far——

Mr. RUSCHE. It is true, but on a scale of 100, they are between 95 and 100.

Senator EVANS. Well, I do not think I would put it quite that bad. Let me turn to one final question. You mentioned in your testimony that you are going to observe and monitor in subseabed disposal. I am interested in this as a potential. I have had some opportunity to receive a briefing and some information and what is occurring in subseabed disposal.

Could you describe for me how far you believe that alternative is right now? How much information, how promising does it look and what would it take to get to the point of some decisionmaking as to whether that is a legitimate alternative?

Mr. RUSCHE. The objective of the program is to try to reach a decision on technical feasibility by about 1991. We have slowed up financial participation. You will recall, last year, we proposed in our budget about $12.5 million and the Congress responded, authorizing us to spend, or rather appropriated $6 million. We have, therefore, adjusted the program this year in terms of its pace.

The technical feasibility, I think, has not yet been established. We believe the program has technical merit; and when we began our consideration for this year, we approached it on that basis: that it does have technical merit and we should continue at some pace. We were faced with the question, however, of making a judgment on priorities as to whether to spend those limited few dollars that we have for generic research and development on this program, or on development for dry storage. It did not seem to me to be a very difficult choice to make.

We do not want to abandon the program in the sense of either making a judgment as to a conclusion that we are not prepared to reach, nor do we want to be in a position of holding some future course which we did not think we could accurately predict. So we took the course that we have taken.

I think the technology deserves consideration and what we want to do this year is put the data in a form, conduct experiments and

bring them to an appropriate conclusion that will allow us to proceed down the road if and when we decide that is the case.

Senator EVANS. Mr. Chairman, I will have further written questions that proceed along that line.

Your last statement sounds fine, except if you do not have any money, how are you going to do all of those things, and how much money would it take—if you had your choice—how much money would it take to actively pursue that objective and try to get the answers that you seek?

Perhaps you can respond in written form.

Mr. RUSCHE. Let me give you just a general answer, and I will give you a more specific one in writing, if that is agreeable.

Senator EVANS. Yes.

Mr. RUSCHE. I think that in the range of $8 to $12 to $15 million a year for the next several years, up to 10 years, would probably be required to reach that determination. And, given the particular account and the priorities, I don't think we can afford it right now because it does not produce sufficient short-term benefits. It may well be down the way that we ought to consider it and I would be glad to provide you some additional data.

[The information follows:]

If the solely funds the continuation of the program to determine its feasibility, a minimum of $25–30 million per year would be required for about 10 years for a total of about $300 million. If the present level of international funding could be assured, about 50 percent of the total would be funded by other countries. Given the present plans to terminate the program and the possible withdrawal of several countries from contributing funds to the program, restoration of the full level of international support cannot be assured. With limited funds we are proceeding to document essential data on the subseabed studies in order to preserve the information as a base for future investigations. We plan to issue in 1987 a preliminary assessment of concept feasibiity based on currently available data through cooperation with participating countries.

The CHAIRMAN. Thank you, Senator Evans.

Senator Ford.

Senator FORD. Just a brief question or two. Mr. Rusche, you dedicated three short paragraphs on page 16 to transportation and system integration, and $33.4 million this year and approximately $31 million next year to provide for the development of adequate transportation, in integrated systems for the shipping and management of nuclear waste among various components of the disposal system.

Is there any thought being given to the transportation lanes—I guess I can use that term—that adequate instructions, adequate dissemination of information be given at a point in time before the transportation starts?

Mr. RUSCHE. Yes, indeed, Senator. We have vigorous efforts underway, working with States that are almost certainly to be affected, and with many others who have the potential for being affected in those transportation lanes.

We have developed and are in the process of working with such States on institutional plans, that is, how we interact with the States, provide advance notice, how we work with the States in terms like emergency response, and so forth.

One of the things that I can't help but note is that until we find the site for the repository, or until we agree that we ought to be

proceeding in parallel with an MRS, all of this has to be done in sort of a speculative environment. One of the great values of the MRS is to get some of this pinned down early so that States—for example, your State—would be in a position to know with somewhat greater confidence at least 4 or 5 years earlier just what the transportation scenarios might look like.

Therefore, we would be in a position to be much more effective, much earlier.

Senator FORD. I think you could be effective, but I would think also you should continue to plan on, when the decision is made, that you could trigger this sort of thing because there will be great speculation, great trembling, and I do not think the Russian event, over the last couple of days, encourages many people as it relates to it.

Not only is there a cloud floating over Scandanavia, there is a cloud of concern now floating over the constituency.

Mr. RUSCHE. I think you are exactly right. It is our objective to be right now, and for the intervening days and years ahead, to be as interactive as we can possibly be. And I appreciate your view very much.

Senator FORD. Thank you. We have to go vote, and when we get back, Mr. Vaughan, I certainly have some questions for you.

[Whereupon, a short recess was taken.]

The CHAIRMAN. Under the rules of the Senate, it requires consent to sit more than 2 hours after the Senate has convened. The Senate convened 2 hours and 22 or 23 minutes ago. We are seeking consent on the floor, and I thought it would bring the administration some comfort to know that we have bureaucratic snafus up here.

Mr. RUSCHE. That is a new finding, isn't it, Senator? That is a brand new thought. [General laughter.]

The CHAIRMAN. But the request for permission to sit was temporarily lost; has now been found, they are processing it. They tell me they think it will be favorable. Based upon that hope, I am going to proceed until I am told that my hope is misplaced.

Thank you, Mr. Rusche, for your tolerance, and you, Mr. Vaughan, for your understanding of the schedule problems we have here with the budget on the floor at this time.

There are a few further questions that I would like to ask of you, Mr. Rusche.

You submitted a review of the MRS proposal to key Congressmen and their staffs on December 23. You also solicited comments from EPA and NRC at that same time, as required by the act. What is the nature of the NRC and EPA comments?

Mr. RUSCHE. The comments from NRC were essentially a statement to the effect that based on documents, they thought the facility was licenseable, and, of course, that is not the issuance of a license, but rather a review of the documents indicates that they did not see any major problems in complying with 10 CFR 72. I think that is the essence of the Commission's documents.

They recognize that at least some of the sites we looked at had prior Commission review and that would certainly enhance the Commission's review process.

They noted that the design of the facility, which is a surface facility, didn't involve any new or unusual structural, physical features and so forth. They did note a number of procedural items that we would need to review and take a look at.

EPA, in a somewhat similar set of conclusions, concurred that the course that we had selected was an appropriate one and that they thought our recommendation for an MRS as an important element of the system was appropriate, and thought that they would be able to work with us in a way that would allow us to proceed.

The CHAIRMAN. In effect, they were positive?

Mr. RUSCHE. Both sets of comments were positive and favorable.

The CHAIRMAN. All right. Is the review copy of the proposal essentially the same as the proposal DOE would have submitted on February 10?

Mr. RUSCHE. Yes, sir; essentially so. I think that there is one variation that we found a need to address and that was how we handled western fuel. In the final proposal, we address that a little more explicitly than we had in the draft.

I think that was probably the major consideration that was different.

The CHAIRMAN. There has been a discussion of this subject, but I want to ask a question, perhaps to get at it in a slightly different way.

When do you expect to formally submit the MRS proposal to the Congress?

Mr. RUSCHE. When the Court acts.

The CHAIRMAN. Presumably when the Court acts favorably?

Mr. RUSCHE. Excuse me. Yes, sir. I am sorry.

The CHAIRMAN. The Court has already acted.

Mr. RUSCHE. You are exactly right. When the Court removes the injunction.

The CHAIRMAN. All right. Do you have any concern that an MRS might detract resources from the repository program?

Mr. RUSCHE. No, sir. On the contrary, I think it might even enhance the program. It certainly will not detract.

The CHAIRMAN. If the act did not require study of a second repository, how could an MRS affect the need, timing, and location of a second repository?

Mr. RUSCHE. If you recall, the act, as currently written, limits the capacity of a first repository to 70,000 tons. We envision the MRS as not providing long-term storage, but would have lag storage of about 15,000 tons. So, in some sense, that would provide a small increment of interim storage.

I think, in addition, to the extent that one of the objectives of Congress was to see some sort of geographic equity, the location of the MRS would certainly be in a part of the country which would tend to serve that purpose.

Of course, I think the major question that we both recognize is that from an operational standpoint, whether we had one or two repositories, the MRS, we believe, would be a major addition to the operational capability of the system.

The CHAIRMAN. Mr. Rusche, I have some further questions to submit for the record for response in writing. I suspect other members of the committee will also request, and hope for prompt re-

sponse. All members may have until close of business tomorrow to submit such questions in writing.

Senator Hecht?

Senator HECHT. Mr. Rusche, has the Department's High-Level Radioactive Waste Disposal Program been adequately funded through the nuclear waste fund?

Mr. RUSCHE. Yes, sir, we believe so.

Senator HECHT. What has the Department done in recent months in response to Court action to provide more funds for States that are possible hosts for high-level waste repository?

Mr. RUSCHE. I believe you are probably referring to a decision by the ninth circuit, with respect to funding States to do independent research or independent investigation. The Court provided us some very specific guidelines.

We have incorporated those within our siting—within our financial guidelines and we have received enlarged, or enhanced, requests from your State and other States, and we are about to close on a major portion; in fact, we have closed on a major portion of your State's most recent request, and I believe this week we will work out the final details on that portion with respect to doing independent research.

Senator HECHT. Has the Department broadened its view of what constitutes appropriate State involvement in site characterization?

Mr. RUSCHE. The Court certainly broadened our view—our original view—by telling us that our original view was wrong. To that end, the answer must be yes.

I think, though, again, your State was the first to make such a request and we are learning together as to how we evaluate and what kind of criteria ought to be applied. I think that is a broadening experience, as well.

Senator HECHT. To what are you alluding? Would you expand on that?

Mr. RUSCHE. I think the States probably—and your State certainly is one of them—have a view about what is appropriate and timely in conducting such independent research. And we have a view. It is a discretionary action. The Court did not say it must meet 19 different tests. It said it must meet the test of appropriateness and technical adequacy, and necessity for conduct at this time in order to be in position in 1991 to exercise the disapproval decision.

So this introduces a number of detailed factors that you don't think about until you begin to consider a specific proposal. And in that sense, I think it is a constructive activity.

I know some of the States, and yours in particular, wish it were not so constructive and did not take so long, but I think we have an obligation to you and to the public to try to do it well.

Senator HECHT. Has there been any development——

The CHAIRMAN. Senator, would you yield?

Senator HECHT. Yes.

The CHAIRMAN. I hate to interrupt you. We have received permission to sit, so we will continue the hearing. Thank you.

Senator HECHT. Has there been any development since the last time you appeared before us, as far as our State and your agency?

Mr. RUSCHE. We have continued work which will lead to the final publication of an environmental assessment with respect to your site which will be under consideration by the Secretary. That work has been essentially completed.

I think that is the biggest part of the activity.

Senator HECHT. When will this be out?

Mr. RUSCHE. It should be out in the next few weeks. Mid-May is the date that I have indicated to you and to the State.

Senator HECHT. That soon. That is 2 weeks.

Mr. RUSCHE. Yes, sir.

Senator HECHT. So you are moving right ahead on it?

Mr. RUSCHE. Yes, sir.

Senator HECHT. Are you and the State working together?

Mr. RUSCHE. Yes, sir.

Senator HECHT. Why the laugh?

Mr. RUSCHE. I thought maybe you knew something I didn't know.

Senator HECHT. No.

Mr. RUSCHE. We work together, but I suspect our view as to how effective it is may be different.

Senator HECHT. Well, I am sure we can get it together.

Mr. RUSCHE. We are going to work, and continue to work together, and appreciate your interest, sir, and concern.

Senator HECHT. Senator Warner?

Senator WARNER. Thank you, Senator Hecht. I would like to say at the beginning that the reports from the State of Virginia, certainly with respect to you, individually, Mr. Rusche, are that you are fulfilling your responsibility as a public servant dealing with a most difficult and emotional task in a commendable manner.

I wish to thank you for your willingness to engage in open discussions with Governor Baliles, the distinguished Governor of the Commonwealth of Virginia, and local officials and citizens with respect to this program and plans for further study of these identified sites.

Mr. RUSCHE. Thank you, sir.

Senator WARNER. The Commonwealth of Virginia has submitted their comments on the Department's draft area recommendation.

Mr. RUSCHE. We have received them.

Senator WARNER. For the crystalline repository project, and I would ask that you review fully the technical information provided in the State's——

Mr. RUSCHE. You can be sure, sir.

Senator WARNER. I refer particularly to the information indicating that the Bedford site lies in an area prone to severe flooding, and that the Halifax, PA, site is within 2 miles of a major geological fault that DOE apparently did not identify in their own maps. And, third, that the candidate site in the Hanover-Louisa-Goochland area is bordered by two geologic megafaults—Virginia's most active earthquake zone.

Do you have any comment to that?

Mr. RUSCHE. All of those factors, Senator, could affect our judgment as to the appropriateness of those sites. They certainly have the potential for being adverse conditions, of some degree. I find myself, or we find ourselves in the awkward position of being criticized because we didn't know all the answers. But, I have to say

that even with that criticism, going through the kind of public process that we have gone through, even with all of its agony, if it turns up information that we missed—for whatever reason—I think we must both agree that the value of that process is justified. To that end, we appreciate what your State and its geologists and others have done. And we will give full consideration to that data and weigh it in the most careful manner we know.

Senator WARNER. I thank you, Mr. Rusche. Indeed, I have been in public life almost a quarter of a century in various capacities, and this is agony for the citizens of those areas because it has substantially dampened their ability to provide for economic development of those areas of my State. It is reassuring to hear you say this morning that the facts evolving from this process, difficult as it may be for the citizens and yourself, are facts which may not have been known prior thereto by the Department of Energy, but will now be carefully assessed as the Department proceeds with their determination.

I see that the next step for the second repository is the release of the final area recommendation report. Then DOE will work to begin the "area phase" activities for field investigation, which is actual onsite work on the identified sites.

How will DOE perform onsite investigations on land privately owned, particularly in situations where the landowner may object and any work DOE needs to perform happens to be on his or her property?

Mr. RUSCHE. Senator, I don't think that we can prescribe a rigorous detailed procedure to start with. Obviously, we will work on those lands, hopefully, in cooperation with and with the approval of the parties who own the land, and we are obligated to honor those rights.

If it turned out in the end that there was some very crucial piece of information, then we would have to look to other procedures, but that is so far down the road in the program that I hope we don't have to consider it and I think that we serve neither your purpose nor their purpose by trying to "what-if" that situation so far in advance.

Senator WARNER. You will comply with local law and the rights of citizens.

Mr. RUSCHE. Indeed, we will.

Senator WARNER. And abide by that law.

Mr. RUSCHE. Yes, indeed. And if I may inject a comment that I guess I am drawn to every time I have this discussion—and I have been having a lot of them, as you know—I think the framers of the act, yourselves, must have had some sense of the need to try to avoid the agony of uncertainty that attaches to an action such as we are talking about, and weighed that against the value of full consideration and public participation, or else the act would not have been written the way it is.

There clearly, are other courses we could have taken, and the act could have taken, but I think on balance, when you look at what we are doing and what the act specifies that we do and how this is being viewed in the world, that we are really living out an open, democratic process on this matter and it is a very difficult choice between these conflicting interests. We want to stay closely in

touch and evaluate the schedule, evaluate the circumstances at every step of the way and we will do our best to keep you informed.

Senator WARNER. Well, I think that is a very commendable attitude that you have expressed here.

The 1982 Nuclear Waste Policy Act imposed a cap on the volume of radioactive waste to be stored at the first repository at 70,000 metric tons. As you may know, I, together with Senator Mitchell and others, are cosponsoring S. 2354. The purpose of that bill is to allow the disposal of all waste at the first repository.

Is there any technical reason that you know of to limit the storage to the 70 K ton metric ton level, or could the sites under study for the first repository hold a greater volume of waste?

Mr. RUSCHE. Our best information is that all of the sites that are currently under study for the first repository could probably accommodate more than 70,000 tons. I think the confidence we have varies from site to site and that is clearly a subject that will become more evident as we characterize the sites and mine down into the rock or salt, or whatever it might be.

But I think the short answer is that we believe that all of the sites have the capacity to accept more than 70,000 tons, and how much more, I think we will have to wait a see.

Senator WARNER. You say you would have to wait. What fact-finding do we need? Senator Mitchell and I are anxious to have this bill considered actually by this committee, and, of course, we called upon the Department for their technical advice.

Mr. RUSCHE. I think we can provide opinions today for each of the sites under consideration, but we would have to recognize that there remains some possibility that when you do the actual characterization that our judgment, based on limited data from the surface, might be replaced by new data when we get down to the actual depth and horizon in the particular rock.

The real question is, is the rock big enough, strong enough and able to dissipate the heat and provide the isolation. We think the answer is yes based on the knowledge that we now have, but that will not be as confident as we would all require until we get some more data.

Senator WARNER. We did make, presumably, the determination that 70 K was safe.

Mr. RUSCHE. We have selected the sites with the expectation that 70 K could be met for all of the sites. Obviously, we can't be that precise. Some of them perhaps have the capability of twice that. And that is what I mean by, "we will have to wait and see."

Senator WARNER. Certainly the ability to transport radioactive material, safely, whether by rail or on the Federal highway system is equally as important as the safety at the permanent repositories. To what degree has DOT's Office of Hazardous Material involved with DOE in planning for the transportation of radioactive waste?

Mr. RUSCHE. That particular office, I have to profess not quite a clear view of where they sit. The director of the research—let me just check.

There is an office in the Department of Transportation which oversees hazardous waste and the shipment which would include nuclear waste, as to the acceptability of routes and roads and

bridges, and so forth, and we are fully subject to that for shipment of this material.

Senator WARNER. What you are answering is that the DOE is coordinating with DOT as it begins to work out this plan?

Mr. RUSCHE. Without question.

Senator WARNER. As DOT has been responsible for coordinating the transportation of hazardous material, I think their experience would be highly useful and I am reassured by your response.

Who notifies State emergency offices or local officials if radioactive material were to travel through their State? What kind of information is shared with State and local officials should a transportation accident or a breach of radioactive material during transportation occur?

Mr. RUSCHE. In general, the shipper or shippers responsible which, in this case would be our office. We make such notifications and work with the States to assure that they receive the appropriate information on a timely basis.

Senator WARNER. I will have some other questions, but our second witness has been most patient. Mr. Chairman, do you think we should turn to him?

Senator HECHT. Thank you for the promotion.

Senator WARNER. Well, that is all right.

If there are no further questions to be directed to Mr. Rusche, we thank him. The committee will now turn to Mr. Vaughan for the presentation of his direct testimony.

STATEMENT OF JAMES W. VAUGHAN, JR., ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY

Mr. VAUGHAN. Thank you, Mr. Chairman. I am pleased to have the opportunity to follow Mr. Rusche and in this case to summarize the Department's Nuclear Energy Supply Research and Development and Uranium Enrichment Programs.

These programs have a broad scope of significant importance to our Nation. We appreciate the interest of this committee, not only in these programs, but in the legislative initiatives that support them that are currently underway regarding Price-Anderson and nuclear licensing reform.

Accordingly, what I would like to do is provide an abbreviated summary of the programs of interest, focusing on what I believe are the concerns of this committee. I have prepared a detailed written statement, which I would like to have entered into the record.

Senator WARNER. Without objection.

Mr. VAUGHAN. The Department places high priority on assuring that nuclear energy contributes to a strong, stable, and secure national energy base to meet both our civilian and our military requirements.

Our reactor development programs to help preserve the nuclear option, and our execution of a reliable, competitive, and business-like uranium enrichment enterprise are an integral part of that commitment.

The Department also remains strongly committed to protecting public health and safety and to assuring a safe and clean environ-

ment in connection with its activities. Our remedial action and waste technology efforts are an integral part of that commitment.

The detailed funding levels for our programs are tabulated in my prepared statement and I won't reiterate them.

I would note that while the overall fiscal year 1987 energy supply research and development budget increases slightly from our fiscal year 1986 estimate, there have been some shifts in the relative funding for the individual programs.

There are several key factors that have influenced the formulation of our programs and budget request that I would like to highlight.

First, the Department is fully committed to support the bipartisan effort to control and reduce the Federal deficit. Second, our space and defense nuclear energy needs are increasing as was planned. Some of the activities have progressed from the design and screening phase into the more funding-intensive hardware phase.

Third, our civilian reactor research and development program is more sharply focused since the currently anticipated timing for the commercial introduction of innovative reactor technologies, beyond light-water reactors, has been stretched out.

Fourth, although the remedial actions and waste technology budget does increase by some $64 million compared to fiscal year 1986, this increase is less than previously forecast. The program objectives can be achieved at that requested funding level by extending the authorization period for the Department's Uranium Mill Tailings Remedial Action Program.

And, finally, the uranium enrichment budget request reflects several strategic budget request items and decisions which were made by the Department during the past year.

Against this background, let me turn to a few of the key issues and highlights of our nuclear energy R&D programs. We have provided R&D support for both the defense and civilian nuclear energy areas for decades. Both areas will continue to be served by our proposed programs which will be integrated and coordinated so as to minimize overall costs.

The priority of defense nuclear energy programs for military applications has not changed. Those programs related to the strategic defense initiative have expanded and moved ahead as planned, while overall funding stringencies have tightened.

Therefore, in the face of the urgent need to reduce Government outlays, the Department has recommended an adjustment in the pace of the Advanced Civilian Reactor Development Program, one which we believe will still keep us ahead of market needs for the types of reactors involved.

Turning for a moment to light-water reactors, which is the subject we discussed at the beginning of this hearing, the technical support for demonstrating removal of the remaining technical, licensing, and institutional impediments to the next generation of LWR's, as well as for innovative advanced reactors , is a key and important objective of our R&D programs.

Our light-water reactor R&D program is focused on essential safety and reliability research and development which can help fa-

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cilitate efforts by U.S. industry to usher in a new, advanced generation of nuclear powerplants of this type.

We believe the time is ripe for completion of development and certification of advanced state-of-the-art light-water reactor designs. In fiscal years 1987 and 1986, the Department, through competitive contracting and in cooperation with EPRI, will be providing selected technology support for these advanced designs through cost-shared programs.

We believe these efforts, along with those which this committee is appropriately taking the lead regarding licensing reform, are essential to restoration and revitalization of the nuclear option in this country.

In the advanced civilian reactor research and development area, we have made excellent progress in our high-temperature gas-cooled reactor and liquid metal reactor design work in the past 2 to 3 years.

Focus is now upon key features affecting the economic, passive safety and technical issues of these concepts to preserve their potential for the future, including the potential application of liquid metal reactors as breeder reactors when our supply of uranium becomes either too short or too expensive.

The advanced reactor program for fiscal year 1987 and beyond will build on the substantial progress made in this technology and design effort over the years.

The space and defense power systems segment of our program is structured to respond to requirements identified by NASA and the Department of Defense, including particularly the Strategic Defense Initiative Organization. This cost-shared program activities will provide the design, development, and supporting technology to build compact, high-performance reactors for space and terrestrial applications and dynamic isotope power systems for space application.

With your permission, Mr. Chairman, I would like to provide for the record a letter which I recently received from General Abrahamson outlining the SDIO's strong support for these joint programs.

The CHAIRMAN. That will be made a part of the record.

[The letter follows:]

DEPARTMENT OF DEFENSE
STRATEGIC DEFENSE INITIATIVE ORGANIZATION
WASHINGTON, DC 20301-7100

29 APR 1986

Mr. James W. Vaughan, Jr.
Acting Assistant Secretary
for Nuclear Energy
U.S. Department of Energy, NE-1
Washington, D.C. 20585

Dear Mr. Vaughan:

As a result of our discussion last week, I would like to re-emphasize my support for several nuclear energy programs that are important to the overall success of the Strategic Defense Initiative (SDI). These programs include the SP-100 and Multi-megawatt (MMW) space reactors, the Dynamic Isotope Power System (DIPS), and the Secure Military Powerplant Project (SMPP).

Space reactor systems will be required in the SP-100 power range in order to satisfy the space platform operational power requirements of a space based SDI system. Higher power MMW space reactors are also candidates to meet the pulse power needs of several of the Directed Energy Weapons (DEW) and Kinetic Energy Weapons (KEW) currently being investigated. Key technology and development issues should be addressed in both programs and the ongoing SP-100 Ground Subsystem Test Program and nuclear MMW development programs need to be continued to address these issues.

The DIPS and SMPP Programs are primarily U.S. Air Force initiatives, but because of their potential application to SDI, I endorse them and urge your continued support as part of your cooperative efforts with the Air Force. The DIPS concept is the preferred power source for an operational Boost Surveillance and Tracking System (BSTS) and development should proceed on a time scale that is compatible with overall BSTS development. As part of my overall funding support for BSTS, some SDI funding will be directed toward DIPS development.

As I indicated to you in an earlier letter, the SMPP may be important to ground based SDI assets. The ground based systems are receiving increased emphasis and I encourage you to continue this cooperative effort with the Air Force. Because it is more of a new application of existing technology rather than a new technology or feasibility issue, Air Force funding is more appropriate than direct SDI funding, and I am relying on Air Force funding to help carry this project forward.

As you consider the various program alternatives that the rigid budget constraints force you to consider, I urge you to give a high priority to these programs that are important to the Strategic Defense Initiative.

Sincerely,

James A. Abrahamson

James A. Abrahamson
Lieutenant General, USAF
Director

Mr. VAUGHAN. And I would also note, Mr. Chairman, that we are pleased that you have invited Colonel Hess from that organization here today to add his support and to comment on these particular programs.

Therefore, I will be brief, but would note that in the space and defense area, our SP-100 space reactor program is moving into the 5-year ground engineering test phase based on reference missions that have been established by SDIO.

The multimegawatt space nuclear power program concentrates on the evaluation of potential multimegawatt space power concepts and the testing and development of enabling technology which could lead to a reference concept by 1991.

Our small nuclear power source demonstration project will demonstrate in fiscal year 1986 performance of a reactor subsystem that can be an alternative to conventional power systems for applications such as the North warning system, which is an upgrade of the DEW line across northern Canada.

Lastly, as part of our multimegawatt terrestrial reactor project, DOE will design a passively safe 10 megawatt electric hardened nuclear powerplant to meet needs which have been identified by the Air Force, as well as potential applications by the SDI organization.

We have, for your information, also had a number of expressions of interest from the civilian sector regarding this concept. I am pleased to report that a request for proposals for this joint department Department of Defense/Department of Energy project have recently been issued and there is a good deal of interest in this effort.

Turning to our Advanced Nuclear Systems Program, you are aware that its objectives are to develop and demonstrate and to deliver radioisotope power sources for U.S. military and civilian space and terrestrial missions. The so-called RTG's which were developed for the Galileo and Ulysses missions passed all their tests and they are ready for possibly a 1987 launch when that rescheduling effort occurs.

In the future, NASA and DOD are continuing to ask us to pursue the technology and the development of advanced RTG's that offer promise of higher power density and greater size adaptability as mission requirements change.

I would also note with regard to our Reactor Development Program that the accomplishments and activities of our facilities and test programs are significant. There have been significant accomplishments at our facilities both in the State of Washington, and in your home State of Idaho, Mr. Chairman, and they are articulated in my written statement. I won't elaborate on them here.

I would note that operation of these facilities continues to make very significant contributions to both United States and international liquid metal reactor operating experience and does provide testing capabilities that are required for the development of nuclear energy sources that will be needed not only for civilian, but for space and military applications.

Turning now to the area of our Remedial Action and Waste Technology Program, I would simply note that my written statement contains detailed information on each of the projects that are

under way, that the emphasis in all of these remedial action programs will continue to concentrate on cleanup activities at the highest priority sites, and on the continued protection of the public and the environment at all sites.

Let me conclude with the summary of our uranium enrichment activities. Our fiscal year 1987 budget request for that program is approximately $1.05 billion in budget authority which will be fully offset by $1.29 billion in projected revenues.

In addition, the DOE budget proposes to return $235 million to the Treasury in fiscal year 1987 as a partial payment of prior Government investment in the uranium enrichment enterprise. We are, of course, mindful of the recently passed Budget Reconciliation Act which includes lower targets for payments to the Treasury and are currently analyzing the detailed provisions of that act versus our fiscal year 1987 proposal.

Our primary objective in this program is to retain a competitive, financially healthy uranium enrichment supply capability in the United States for the long term.

We think we have made important progress in achieving the seven major goals which we established for that enterprise as were articulated in our June 1985 strategy, announced by the Secretary, and as contained in my written statement.

Most importantly, we have stabilized the uranium enrichment market and become more cost competitive. We have improved the efficiency of our production operations, placed the Oak Ridge gaseous diffusion plant in standby, and cancelled the gas centrifuge enrichment plant. We are continuing to conduct a rational R&D program to develop the world's most advanced enrichment technology, which goes under the acronym of AVLIS.

The net result of all these actions is that we have been able to increase our share of the free world enrichment market from about 46 percent in 1985, to a projected 53 percent in 1990. But there is much more to be done and we consider that the next 2 years will be critical for the uranium enrichment enterprise as we enter the third phase of our strategy, that of stabilizing the enterprise for the future.

During this fiscal year and the next, we will develop the institutional framework that we trust will assure that the Nation continues to have a reliable supply of enrichment services for the long term.

One key action that has recently been initiated is the proposed modification of the uranium enrichment services criteria, and since I covered this subject in some detail in my April 10 testimony before this subcommittee, I will not elaborate except to add a note that we did publish on April 25 an additional analysis regarding the recovery of prior Government costs and requested further public comment on this supplementary information. We still hope to complete the rulemaking process by the end of this year.

Additionally, we requested earlier this month expressions of interest from the private sector concerning potential participation in the uranium enrichment enterprise. This request for private sector expressions of interest is clearly exploratory in nature, and while our action is part of a broad administration initiative to evaluate the transfer of certain Federal functions to the private sector, let

me again assure the subcommittee that no decisions have been made by DOE regarding the sale of any uranium enrichment assets.

This completes my statement, Mr. Chairman, I would be pleased to respond to your questions at this time. I do have with me four of my principal colleagues for the various programs I have outlined, and if we need, we can invite them to the table to assist me.

[The prepared statement of Mr. Vaughan follows:]

STATEMENT OF
JAMES W. VAUGHAN, JR.
ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY
U.S. DEPARTMENT OF ENERGY
BEFORE THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
U.S. SENATE

APRIL 29, 1986

Mr. Chairman, I am pleased to have the opportunity to discuss the Department of Energy's FY 1987 budget request for Nuclear Energy Supply Research and Development and Uranium Enrichment programs.

The requested funds are distributed among the program elements as summarized in the following table:

	--($ in Millions)--	
Program Element	FY 1986 Estimate	FY 1987 Request
Nuclear Energy Supply R&D		
Nuclear Energy R&D	$ 375.7	$ 330.9
Remedial Actions and Waste Technology	$ 230.0	$ 294.1
Policy and Management	$ 1.7	$ 1.8
TOTAL	$ 607.4	$ 626.8
Uranium Supply & Enrichment Activities		
Uranium Enrichment Activities	1,550.4	1,051.4
Payback to Treasury	0*	235.0
Uranium Enrichment Revenues	1,360.6	1,286.4
Net Uranium Enrichment	$ 189.8	$ 0

* Revenues in excess of outlays of approximately $110 million will accrue to the Treasury in FY 1986.

A more detailed funding table is included in the discussion of each major program. The FY 1986 figures in these tables reflect appropriated totals reduced by sequestrations responsive to Public Law 99-177 (the Gramm-Rudman-Hollings Deficit Reduction Act), management initiatives, and other general reductions. The FY 1987 Uranium Enrichment request reflects both planned partial payback of prior Government investment and offsetting revenues, resulting in a net zero appropriation for that activity.

OVERVIEW

We place high priority on ensuring that nuclear energy continues to contribute to a strong, stable, and secure national energy base to meet both civilian and military requirements. Nuclear energy, along with fossil and renewable energy sources, are essential elements to achieving that goal at reasonable cost. The Department's commitment to nuclear energy remains strong. Our reactor development programs to help preserve the nuclear power option and our execution of a reliable, competitive, and businesslike uranium enrichment enterprise are an integral part of our commitment. The Department also remains strongly committed to protecting public health and safety and to assuring a safe and clean environment in connection with its activities. Our remedial action and waste technology efforts are an integral part of that commitment.

In assessing our FY 1987 nuclear energy program priorities, we have faced hard choices for many of our program elements in a time of fiscal constraint. While the FY 1987 budget request for Nuclear Energy Supply Research and Development programs increases slightly from our FY 1986

estimate, there have been several shifts in relative funding levels for individual programs. Within that essentially level budget, our funding request for nuclear energy research and development (R&D) has decreased by about $46 million, while funding for Remedial Actions and Waste Technology has increased by some $64 million compared to FY 1986.

Key factors that influenced the formulation of our programs and budget request include:

First, the Department is fully committed to support the bipartisan effort to control and reduce the Federal deficit. In this necessary environment of fiscal constraint, we are constantly faced with difficult choices among deserving programs. Although it may appear to some that worthwhile R&D elements have been eliminated or significantly reduced, we believe that each of our programs is sharply focused to make optimum use of limited resources.

Second, space and defense nuclear energy needs are increasing, particularly those associated with the Strategic Defense Initiative (SDI). Some of our activities in this area have progressed from the design and screening phase into the more funding-intensive hardware phase. These activities are an essential part of a top national priority. Accordingly, our funding request for these efforts in our nuclear energy R&D programs has increased in FY 1987 as previously planned. Certain benefits derived from the nuclear energy R&D work to support these national security requirements will be applied to future civilian reactor development efforts and complementary base technology activities will continue.

Third, our civilian reactor research and development program has been reduced, but more sharply focused on assuring that a path exists to maintain nuclear power as a robust option for the rest of this century and beyond. Last year, we testified that the institutional and technical impediments to the near-term deployment of light water reactors must be overcome before there would be any chance to realize the potential of advanced reactors. This is reflected in the priorities within the funds available for reactor research and development. Our Light Water Reactor (LWR) R&D program is more sharply focused on research and development which can help facilitate efforts by U.S. industry to usher in a new, advanced generation of nuclear powerplants. The Department's LWR R&D programs will continue to emphasize advances in safety technology including continued evaluation of the Three Mile Island accident. It is our view that the time is ripe for the completion of development and certification of advanced, state-of-the-art LWR designs. Certainly the currently anticipated timing for the commercial introduction of innovative reactor technologies beyond light water reactors has been stretched out. We have made excellent progress in the past 2 to 3 years on design work for High Temperature Gas Reactors (HTGRs) and Liquid Metal Reactors (LMRs); our focus is now upon key features affecting the economic, passive safety, and technical issues of these concepts. Our funding request for civilian advanced reactor development activities has been reduced in FY 1987 consistent with this extended timing and other nearer-term priorities including space and defense activities.

Fourth, the Remedial Actions and Waste Technology budget request increases by $64.1 million compared to the FY 1986 estimate. The program objectives can be achieved at this level of funding by extending the authorization period for the Department's Uranium Mill Tailings Remedial Action (UMTRA) Program from March 1990 until the end of FY 1993, consistent with the guidance provided in House Report No. 99-195 accompanying the FY 1986 Energy and Water Development Appropriations Act (Public Law 99-141). We will formally request such an extension later this year. Emphasis in all remedial action programs will concentrate on cleanup activities at the highest priority sites and the continued protection of the public and the environment at all sites.

Finally, the Uranium Enrichment budget request reflects several strategic decisions made by the Department during the past year. Chief among these are placing of the Oak Ridge (Tennessee) Gaseous Diffusion Plant in standby, termination of the Gas Centrifuge Enrichment Plant (GCEP) project, and selection of the Atomic Vapor Laser Isotope Separation (AVLIS) process as the advanced uranium enrichment technology for the U.S. in the 21st Century. The FY 1987 budget request reflects these decisions. During FY 1986, the Department will initiate an effort to evaluate possible private sector participation in the enterprise, including development and ultimate deployment of the AVLIS technology.

More detailed discussion of these factors and the scope, status, and budget request for our programs is contained in the sections that follow.

NUCLEAR ENERGY RESEARCH AND DEVELOPMENT

The funding request for Nuclear Energy Research and Development is contained in the following table:

Program Element	FY 1986 Estimate ($ in Millions)	FY 1987 Request ($ in Millions)
Nuclear Energy R&D		
Light Water Reactors	$ 48.1	$ 41.0
Advanced Reactor R&D	128.5	49.5
Space/Defense Power Systems	20.2	71.7
Advanced Nuclear Systems	19.5	23.6
Facilities	132.2	121.8
Water Cooled Breeder	19.0	13.6
Program Direction	8.2	9.5
Total	$ 375.7	$ 330.9

The Department has provided R&D support for both the defense and civilian nuclear energy areas for decades and both areas will continue to be served by these proposed programs. It is our intent to integrate and coordinate those efforts to the maximum extent practical so as to minimize the overall cost. The priority of defense nuclear energy programs for military applications has not changed; programs have expanded and moved ahead as planned while the overall funding stringencies have tightened. Two factors are at work. One is the decrease in orders by utilities for new nuclear generating capacity resulting in a relaxation, which may be temporary, of the urgency for advanced reactor technology for civilian applications. The second is the emergence of the Strategic Defense Initiative and its multiple concepts for which advanced nuclear power technology is frequently the most advantageous choice to meet power source needs. In the face of the urgent need to reduce Government outlays, the Department has

recommended an adjustment in the pace of the civilian reactor development program and use of existing capability to meet growing space and defense needs rather than initiate the buildup of a new, separate, and costly program capability unique to space and defense applications. Our programs in support of military and civilian energy needs are complementary. Certain benefits that accrue from each program will be applied to other programs. The principal areas of interface are in application of common technology, facility utilization, and shared use of available expertise in our laboratories and contractors.

Our advanced reactor R&D program builds upon significant past success to focus upon key features related to safety and economics of advanced reactor systems. Application of improved state-of-the-art LWRs represents the most likely path to revitalizing the nuclear power option. Emphasis in our LWR program is on supporting a process leading to enhanced safety; improved, more predictable licensing; and certification of advanced LWR designs.

Supporting all of these R&D efforts will be the continued operation of the unique test facilities and analytical laboratories required for developing and verifying advancements in reactor systems, fuel, components and power conversion systems.

The FY 1987 nuclear energy R&D program consists of the following elements: Light Water Reactors, Advanced Reactor R&D, Space and Defense Power Systems, Advanced Nuclear Systems, Facilities, and Water Cooled Breeder.

A discussion of each of the program elements that comprise the FY 1987 Nuclear Energy R&D budget request follows.

LIGHT WATER REACTORS

From the experience accumulated to date on LWR research, design, construction, operation, and regulation, it is evident that major national benefits can be realized by near-term advancements in each of these areas. Consistent with industry responsibilities, programs are already underway by the reactor manufacturers and the electric utility industry to exploit these opportunities for existing LWR's and, to some extent, for LWR's yet to be committed. The Department's LWR program in FY 1987 will provide additional technical confidence that the benefits of evolutionary improvements to existing LWR's are realized, and will explore the impact and benefits that can be expected from the application of additional R&D efforts to bring more standardized, advanced, state-of-the-art LWR's to fruition in this country within an improved licensing and regulatory system.

The technical support for demonstrated removal of the remaining technical, licensing, and institutional impediments to the construction and operation of next generation LWR's, as well as innovative advanced reactors, is a key objective of our R&D programs. A key milestone in the pursuit of this objective will be to achieve Nuclear Regulatory Commission (NRC) certification of at least two Advanced Light Water Reactor (ALWR) systems in approximately 5 years. The pursuit of this objective will have the effect of focusing and guiding the Department's efforts in the LWR program area. The major areas of work in the LWR program element are LWR Safety and Licensing, Advanced LWR Technology, and Three Mile Island (TMI) R&D.

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LWR SAFETY AND LICENSING

By 1987, more than 100 nuclear powerplants will be generating approximately 17 percent of the Nation's electricity. The use of nuclear power has substantially increased our energy security by greatly reducing the dependence on imported oil. A maximum of 14 additional units are scheduled to come into operation in the United States between 1987 and 1992.

Even with this impressive use of nuclear power, further deployment of this important energy option is threatened. One of the major reasons is the U.S. regulatory system, viewed by many as slow, cumbersome, and ineffective. The central requirement in the Federal regulatory scheme is to assure public health and safety through regulation of nuclear powerplants. Effective regulation consists of a technical component and an understanding of economic impacts of the means used to regulate. The changing positions, policies, and regulations affecting the LWR industry have rendered the technology of decreasing value to end users. Clear and consistent policies and supporting technical bases for LWR construction and operation will provide the framework for a coherent regulatory policy at both the Federal and state levels. Industry must be able to meet the legitimate requirements of regulators at the state and Federal level. However, the regulatory process itself needs to be more responsive to the energy needs of the next decade and beyond by dealing with safety and licensing matters on a rational, risk-based technical approach.

One of the tasks in this program area is a continuation of the severe accident technology program. Fuel damage testing conducted during prior

years culminated in completion of the Loss-of-Fluid-Test (LOFT) program in FY 1986. That program provides the basis for further evaluation of fuel damage tests conducted under cooperative programs with other nations. The focus of follow-on work in FY 1987 will be to translate the results of LOFT program results into sound models and data generally accepted by the technical community as appropriate for use in the licensing process.

The overall goal is to develop and apply a severe accident methodology that incorporates results of all recent experimental work and an understanding of the ability of operator actions to reduce the consequences of accidents through more informed decisionmaking in the control room. Effective consensus in this area is crucial to regulatory reform and a better understanding of the requirements for emergency preparedness at both the local and Federal level.

In addition, risk-based licensing techniques will be developed and coordinated with the Nuclear Regulatory Commission's policy on severe accidents. General agreement has been reached on the use of risk-based techniques, and application of such techniques to achieve improvements in the regulatory process is growing. What remains to be done is to apply these techniques in the consideration of design choices for future reactors. Procedures for considering alternative design features or alternative means of complying with safety standards will be developed and applied. Work in this area will provide increased confidence that advanced light water designs meet all licensing and utility requirements for safe, reliable and economic performance.

Another important effort is a cooperative industry/government program to extend the productivity of existing and future LWR's. The equivalent of 20 new light water reactors could be realized through practical improvements in availability and lifetime of existing LWR's. Plant availability programs will be conducted in close cooperation with industry. A DOE aim is to help assure that nuclear utilities have incentives to continue extended fuel burnup previously initiated by DOE, and to apply previously obtained results. Pilot plant studies on a typical pressurized water reactor and a typical boiling water reactor will identify those components and structures that will be key in deciding to extend plant life time. In FY 1987, efforts will concentrate on technical analyses to determine key reactor plant structures and components that can continue in service beyond 40 years without replacement or refurbishment. This program could lead not only to an improved Federal regulatory approach, but could also provide a more informed bases for state regulatory evaluations of the economic and the safety impact of investments in improved plant performance.

ADVANCED LIGHT WATER REACTOR TECHNOLOGY

U.S. firms have participated in major joint programs in Japan to develop a new generation of advanced LWR's in the 1,200-1,300 megawatt electric (MWe) power range. The U.S. electric utility industry has begun a smaller effort to draw upon the results of this program, as part of an effort to set the stage for future deployment of standardized advanced light water reactors by U.S. utilities.

Work on Advanced LWRs includes R&D needed to bring forward a new generation of mid-sized LWRs. In the early 1970's, when the U.S. nuclear industry was thriving on high load growth, assumed economies of scale drove plant ratings from the intermediate range (400-800 MWe) to about 1,000 MWe. With today's pattern of lower load growth rates, plants with smaller ratings and lower total capital cost may be required to meet utility needs. The difficulty of obtaining financing for very large construction projects, impacted in part by continued changes in regulatory requirements for existing product lines, has led some U.S. reactor manufacturers to consider developing smaller, advanced LWR concepts. These designs would build on the extensive experience base from the last three decades of reactor operations but would also incorporate innovative design features. Such features could be less sensitive to changes in regulatory requirements, and also offer reduced construction periods and reduced total plant costs. Because of the relatively large resources needed to develop such designs and the uncertain potential for payoff, these innovative mid-sized LWR concepts have been developed only to a very preliminary stage. Both the market and the regulatory process are too uncertain to practically justify sufficient private sector financial investment necessary to carry the design concepts to a stage at which their potential can be adequately assessed.

In 1985, a cooperative DOE/industry program was initiated through a Memorandum of Agreement with the Electric Power Research Institute (EPRI). The objective is to assure that the lessons from U.S. past experience have been successfully applied to these new mid-sized and large LWR designs.

Through the cooperative efforts of the NRC, DOE, EPRI, utilities, and suppliers, the way can be paved to complete the development and acceptance of both large and mid-sized advanced LWR's as attractive energy options for the future.

In FY 1986 and FY 1987, DOE--through competitive contracting and in cooperation with EPRI--will be providing selected technology support for these advanced designs. The important factors that will be considered in determining DOE support include the degree to which system design improvements reduce the sensitivity of plants to transients, enhance safety margins, improve use of passive safety features, simplify systems to reduce the need for regulatory involvement or oversight, improve the quality of construction, and develop a technical and regulatory basis for improved plant control. I am pleased to report that an initial selection of technical proposals has been made. Considerable industry interest was expressed in participating in a cost-shared program that will explore innovations in LWR technology to help assure that future nuclear power plants can be built on schedule, within budget and conform with the degree of safety and reliability that our citizens have every right to expect.

THREE MILE ISLAND R&D

FY 1986 R&D activities for the damaged TMI Unit 2 (TMI-2) reactor indicate successful movement by the GPU Nuclear Corporation, the nuclear industry, and government toward completing the objectives of the TMI-2 program. Defueling of the reactor has begun and shipments of core debris will be shipped to DOE's Idaho National Engineering Laboratory (INEL) for

examination and storage. The current schedule calls for completion of fuel removal from the original core region by the end of FY 1986 and removal of the remaining fuel from the bottom of the reactor vessel and from the primary system components by the end of FY 1987. Data acquisition--a key element of the Department's TMI R&D effort--will focus on instrumentation and equipment performance, severe accident analyses including the behavior of radioactive fission products, data system and sample archiving, and offsite fuel debris examination. EPRI is providing mechanisms to assist in transferring this technology to industry.

Efforts in FY 1987 will be to conduct the offsite examination of the damaged TMI-2 reactor core at INEL and to transfer the technology to industry. The core examination will provide unique information on full-scale reactor behavior during severe accidents. This work will provide the necessary data for evaluating present licensing criteria and requirements; developing future licensing criteria; and assessing and developing computer models that are necessary to analyze the course and consequences of severe accidents in order to mitigate the effects of such accidents. This program will be completed in FY 1988.

ADVANCED REACTOR RESEARCH AND DEVELOPMENT

At the request of the Secretary, the Energy Research Advisory Board (ERAB) convened a Civilian Nuclear Power Panel in October 1985 to review and comment on the Office of Nuclear Energy's draft Strategic Plan for Civilian Reactor Development. The essence of the draft Strategic Plan is to establish an agenda of requisite actions and tasks to develop advanced

reactor systems that can be acceptable and competitive in a future market. While the pace of the program to fulfill that agenda must be adjusted to accommodate national priorities and funding constraints, it is the Department's intent to continue to operate our unique liquid metal reactor test facilities and to conduct the R&D leading to licensing and potential commercial deployment of advanced reactor systems at an appropriate time in the future. A revised Strategic Plan, based on consideration of comments received from the ERAB Panel, Congress, and others, will be valuable in guiding and focusing DOE's reactor development programs, in helping assure complementary efforts by the private and public sectors, and in maintaining goals and objectives to ensure effective utilization of public funds.

In FY 1986, work will continue on the development of LMR and HTGR designs and their supporting R&D activities. These designs emphasize competitive economics, greater reliance on passive safety, increased tolerance to off-normal events, improved licensability, and shorter construction times. This advanced reactor systems program is aimed at providing alternative means of economic electricity production in the future, including the use of breeder reactors when the market so dictates. Advanced plant design activities are placing emphasis on refining system concepts and plant arrangements. Evaluations are being conducted to enhance the ability of these designs to meet these objectives. FY 1987 will see a further focusing of our effort on key economic and safety aspects of these designs.

Reviews of the advanced designs have been conducted by NRC, and responses have been received regarding the innovative safety approach adopted for these designs. Safety analyses are being prepared for both the HTGR and

LMR designs and will be submitted to the NRC by the end of FY 1986 to support the preparation and issuance of a Preliminary Safety Information Document, which will be the basis for a formal opinion by NRC concerning licensability.

R&D support is being conducted in the areas of long life metal and oxide fuels, materials, advanced component development, development of passively safe reactor shutdown and heat removal systems, advanced plant control systems, inherently safe core designs, and core modification to meet specific program needs. Test support at our facilities is being provided in the areas of long-life core development, inherent safety testing, seismic response, thermal/hydraulic analysis, and system transients.

The advanced reactor program for FY 1987 and beyond builds on the substantial progress made by advanced reactor technology and design R&D over the years. The most important elements of the existing program, including some international activities, are retained, while a portion of the technical capability of the laboratories and test facilities is made available for use in pressing near-term space and defense applications. Safety systems design, advanced fuel cycle concepts, and plant technology R&D are important elements.

Passive safety features are being incorporated into the advanced reactor designs and will reflect advances being made in fuels and core designs. This will significantly reduce the likelihood and consequences of plant failures. Key related activities will be the completion of transient tests in the Fast Flux Test Facility (FFTF) and transient overpower tests in the

Experimental Breeder Reactor II (EBR-II). A key safety test was recently completed at EBR-II when the coolant pumps were shut down with the reactor operating at full power, causing the inherent safety characteristics to take over and shut the reactor down without operator action. The safety systems design activity incorporates the integration of state-of-the-art technology in communications, controls, and operations into advanced reactor designs. Work next year will include development of man/machine interface criteria and associated testing methodology for civilian power, space and defense reactor needs. The advanced fuel cycle activities will continue the progress made towards the objective of extending core life to at least 3 years. The potential exists to achieve much longer core lifetimes with attendant economic benefits. Metal fuels work will be directed to establishing technical feasibility and potential to improve safety margins, fuel cycle costs, and improved proliferation resistance.

The plant technology efforts are focused on supporting the design of a standardized, modular plant that can be shop fabricated. Studies of advanced concepts have shown that standardization can eliminate up to 80 percent of indirect engineering costs. Modularity and shop fabrication are expected to reduce labor costs. The FY 1987 R&D program will include activities in the areas of seismic/shock testing, fuel performance testing, passive decay heat removal, core thermal-hydraulic testing, circulator/pump development, and plant and rod control systems and materials.

Cooperative testing, design, and analytical programs on the breeder and other reactors with European nations and Japan are being continued,

including private sector interactions, in the areas where the applications of results serve our prospective advanced commercial reactor needs.

The advanced civilian reactor development program has embarked on a course destined to develop advanced nuclear systems that meet market demands. Our rate of progress on that course must be tempered by fiscal constraint. However, we have made important progress and our resolve to meet our objectives is undiminished.

SPACE AND DEFENSE NUCLEAR POWER SYSTEMS

The Space and Defense Power Systems program is structured to respond to requirements identified by the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), including the Strategic Defense Initiative Organization (SDIO). Program activities will provide the design, development and supporting technology for building compact, high performance reactors for space and terrestrial applications and dynamic isotope power systems for space application. This work is divided into the SP-100 Space Reactor Project, the Multimegawatt Space Nuclear Power Program, the Dynamic Isotope Power System (DIPS), the Small Nuclear Power Source (SNPS) Demonstration Project, and the Multimegawatt (MMW) Terrestrial Reactor Project. A discussion of each follows.

SP-100 Space Reactor Project

The SP-100 Program was initiated in February 1983, when DOE, NASA, and the Defense Advanced Research Projects Agency (DARPA) formally agreed to

jointly investigate, fund, and--if warranted--develop Space Reactor Power System Technology. The SP-100 Program is a three-phase effort.

Phase I (Technology Assessment and Advancement, FY 1983-1985) involved the investigation of concepts, the assessment and advancement of critical technologies, the establishment of technical and safety feasibility, and the selection of one power system concept for further engineering development and ground demonstration testing at a selected DOE test site during Phase II. This phase was successfully completed in FY 1985.

Phase II (Technology Flight Readiness, FY 1986-1991) involves civil and military mission analysis and requirements definition; detailed design, engineering development, and ground testing of the selected power system concept to demonstrate its safety, performance, dependability, and readiness for dedicated flight use; and pursuit of even more advanced aerospace technology which could further enhance an SP-100 system in the longer term.

Phase III (Flight System Production, Qualification, and Flight Demonstration/Application, approximately FY 1991-1993) will involve flight system fabrication; ground-based flight qualification testing; spacecraft and launch vehicle integration; launch; and actual space flight demonstration/application.

Phase I efforts culminated with the selection of a concept for further engineering development and demonstration testing during Phase II. The selected concept employs a compact, liquid metal cooled, fast-spectrum reactor with out-of-core thermoelectric power conversion. It will be

designed, built, and tested at a reference power of 300 kilowatts electric (kWe). In November 1985, DOE selected the Hanford, Washington, facility as the preferred site at which to conduct the reactor ground demonstration testing.

A Request for Proposals (RFP) was issued in November 1985 to secure a system development contractor from industry by September 1986. That contractor will be responsible for designing, fabricating, and directing the ground testing of a prototype space reactor and other key subsystems. This effort will involve analysis and testing sufficient to demonstrate system performance, safety, dependability, and flight readiness. As an option, this effort additionally includes the provision to produce flight units and provide all the support necessary to expedite a flight program when the initial user commitment is finalized.

Programmatically, a Memorandum of Agreement to establish, manage, and implement the Phase II technology flight readiness program was signed by DOE, DOD, and NASA in early October 1985. Specifically, DOE is responsible for the ground engineering system development. The SDIO is responsible for overall program direction and--with the Air Force as its executing agent--military mission analysis and requirements definition. NASA is responsible for civil mission analysis and requirements definition, as well as for advanced aerospace technology that could ultimately enhance an SP-100 system.

A planned 300 kWe SP-100 nuclear electric propulsion flight demonstration for SDIO in the early 1990s timeframe was established in September 1985.

This reference mission will serve to demonstrate and flight qualify SP-100 for follow-on dedicated mission use. Preliminary reference mission planning will be completed in mid-1986. Funding for this planned flight demonstration has been programmed by the SDIO in their outyear budget projections starting with FY 1987.

The Department is committed to the SP-100 Ground Engineering System (GES) development and testing project as are our other SP-100 partners. Its success will provide a new energy option to mission users in the 1990's and beyond.

Multimegawatt Space Nuclear Power Program

The need for powerful new, space-based defense weapons and surveillance systems for protection against the threat of nuclear missiles has been established as a top national priority. The proposed weapons and surveillance systems require large amounts of electrical power, significantly more than can be provided by current power systems.

The SDIO has established a program to develop nuclear and nonnuclear systems that can separately or in combination meet the SDI multimegawatt power requirements. Responsibility for developing nuclear power system concepts and technology has been assigned to DOE. The Air Force has been assigned responsibility for nonnuclear power systems development.

A key objective of the MMW Space Nuclear Power Program is to identify and develop at least one space nuclear power system concept by 1991 that alone,

or in combination with a nonnuclear power system, meets SDI MMW power requirements and for which technical feasibility issues have been resolved.

To meet the SDI requirements for safe, reliable, compact MMW power sources, significant advances in space nuclear power technology must be achieved. SDI missions such as space-based defense weapons, imaging radars and electric propulsion have high electrical power requirements: hundreds of megawatts for up to 2,000 seconds (burst mode) for some weapons; tens of megawatts for up to 1 year total operating time (alert mode) for imaging radars, weapons readiness, and electric propulsion; and hundreds of kilowatts to a few megawatts for as many as 7 years (continuous mode) for station-keeping activities and surveillance.

During FY 1985 and FY 1986, the program focus has been on developing a MMW Space Nuclear Program Plan and on assessing and investigating various system concepts and related critical technology areas that must be advanced if these reactor system concepts are to be able to meet the power, mass, volume, and longevity requirements of the SDIO. The program plan addresses system requirements, and provides concept and technology overview, program strategy, costs, schedules and milestones, as well as concept and technology developing activities. Work under the plan was initiated in FY 1986.

The FY 1987 effort will continue the evaluation and development of potential multimegawatt space power concepts. In addition, work will continue on experimental testing and development of key enabling technologies that are required if the preferred concepts are to become

fully viable. These experimental testing and development efforts will focus on advanced nuclear fuels, materials, safety, and reliability. Advanced reactor control techniques and neutronics, shielding and thermal hydraulic codes will also be developed.

Dynamic Isotope Power System

The needs of military spacecraft in the planning process include higher power requirements (than achievable through the use of radioisotope thermoelectric generators, or RTG's) and increased survivability to threats directed at disablement or destruction of the space system. The current standard spacecraft power source, arrays of photovoltaic cells, lacks required features of hardness and has too much volume that could constrain the maneuverability of these new space systems. One class of spacecraft of current interest for high priority missions, requires power in the range of 1 to 10 kilowatts of electrical power; stringent attitude control and station keeping; and survival from the threats projected for the 1990 time period. In order to make certain that a highly reliable and efficient isotope powered system in the one to ten kilowatt electrical range is a viable option for military planners, a joint DOD/DOE program is being initiated. Initial DOD funding has recently been received for this program.

The dynamic isotope power system (a combined turbine alternator, isotope-fueled power subsystem) is an enabling technology for these military space missions which require survivability against various threats, higher power missions performance, and a small power supply to improve the spacecraft

sensors field of view and overall spacecraft pointing accuracy. DOD missions such as the Boost Surveillance and Tracking Systems (BSTS) are currently under active mission requirements definition and analysis as part of the SDI program. All of the DOD contractors have recommended the DIPS as the primary power source for the BSTS application.

The goal of the DIPS program is to develop and demonstrate the necessary technology required to provide this type of space electrical power in the range of one to ten kilowatts output for use by these types of emerging military space missions in the mid 1990's and beyond. The specific objective of this development program is to develop the DIPS as a viable enabling technology as the electrical power supply for the SDI space surveillance spacecraft.

Small Nuclear Power Source Demonstration Project

There is a military, and potentially a civilian, need for ground-based power systems that can operate continuously in harsh environments with minimum attendance and freedom from the need for frequent replenishment of fuel supplies such as diesel oil. These systems must have high reliability, low maintenance, long lifetimes, and simplified logistics. Nuclear reactor technology appears to offer feasible and improved alternatives to conventional power systems for such applications as the North Warning System, which is the upgrade of the Distant Early Warning (DEW) line across northern Canada.

Because of the logistics and resupply costs of maintaining diesel generators a reactor power system is being considered as an alternative. Such a reactor system would require only minimum maintenance, and it would potentially result in significant savings in operation and maintenance costs and in overall life cycle costs. An assessment of the concept was undertaken in FY 1984. Based on the positive findings of that assessment, conceptual design efforts on reactors for the North Warning System (now called the Small Nuclear Power Source Demonstration Project) were initiated in FY 1985. The Department of Energy, the United States Air Force (USAF), and Atomic Energy of Canada, Limited (AECL), are jointly funding a program to investigate and demonstrate the feasibility of using a 15 kWe reactor power source for an application such as the North Warning System. In FY 1986, the design is being completed, component development testing is underway, and the demonstration reactor is being fabricated.

In FY 1987, zero power tests will be conducted on the nuclear and heat pipe subassemblies to verify the neutronics performance of the subsystem. The complete system will be installed in a test cell at AECL's Whiteshell facility and system startup tests will be initiated in early FY 1988.

Basically, all of the system components use state-of-the-art technology that has been used in other systems. For example, the nuclear fuel will consist of pellets of the type used in high-temperature gas-cooled reactors, and the organic rankine cycle will be similar to those used on fossil-fueled generators for communications on the Alaskan oil pipeline and for waste heat recovery on several industrial processes. The initial

objective of the program is to place a demonstration reactor in ground testing by late FY 1987.

Multimegawatt Terrestrial Reactor Project

In response to interest by the Air Force (as well as SDIO) an effort is underway which will lead to the design of a hardened nuclear powerplant with a nominal 10 MWe rating. This plant will feature a passively safe design, a capacity factor in excess of 90 percent, refueling intervals which could range from 4 to 10 years, and will be hardened against specified military threats.

The SDIO has expressed interest in such a nuclear powerplant for its ground-based applications. These applications include the command, control, and communications systems that must operate reliably in a hostile environment if the total SDI system is to be credible. The source of power for these systems must be relatively invulnerable to terrorism, sabotage, and electromagnetic pulses from high altitude nuclear detonations as well as to acts of nature, e.g., lightning strikes, snow, windstorms. As the SDI system emerges, it is possible that a significant portion of the detection and weapon systems will be ground-based rather than space-based; these systems will need power supplied from dedicated, secure, and reliable powerplants.

Conceptual design studies of a secure military nuclear powerplant have been performed and found to show that the concept is sound. A request for proposal for advanced design of the plant has been issued. In late

FY 1986, up to two concepts will be selected for detailed design; the preliminary design will be completed by the end of FY 1987.

ADVANCED NUCLEAR SYSTEMS

The responsibility of the Advanced Nuclear Systems program is to develop, demonstrate, and deliver radioisotope power sources for U.S. military and civilian space and terrestrial missions. A recent dramatic application of RTGs was the Voyager 2 fly-by of Uranus--a planet so far from the Sun that it receives less than 0.3 percent of the sunlight received at Earth. In such a region of dark space, nuclear power is the only option for planetary explorers. The RTGs on Voyager 2 are still performing well above the prelaunch predictions over eight years after launch. NASA plans to continue to use RTGs on their next generation of planetary explorers (Mariner Mark II) planned for the 1990s.

Today, RTGs have been built with power levels over 300 watts, so that several could be ganged to provide up to a kilowatt or more of electrical power. Recognizing the usefulness of isotope power, DOD and DOE signed an umbrella agreement in 1985 to foster work on isotope power systems. A supplemental agreement has been prepared to support the BSTS. In cooperation with the Air Force, DOE is planning to develop the dynamic isotope power system for BSTS. However, current Air Force plans call for flying an early BSTS flight experiment to test out the system. Because the flight experiment may require less power than the operational satellites, RTGs are a logical choice to provide dependable, survivable electrical power.

A major effort under the RTG program has been the design, fabrication, and delivery of isotopic power supplies, safety analyses, and planning of launch support activities for the NASA Galileo and Ulysses missions. The four General Purpose Heat Source (GPHS) flight RTGs, including one spare, and 110 radioisotope heater units for thermal control of spacecraft components, have been delivered. Following possible 1987 NASA launchings, DOE will support the mission by continued testing of the qualification and engineering units of the RTGs, analyze RTG mission performance data, and provide NASA with periodic long-range predictions for mission planning.

In looking forward to future NASA and DOD space missions, DOE is continuing to pursue the technology and the development of an advanced RTG that offers promise of higher power density and greater size adaptability as mission requirements change. This Modular Isotope Thermoelectric Generator (MITG) will enable NASA to accommodate a range of interplanetary missions identified by the Solar System Exploration Commission of the NASA Advisory Council. The MITG is also a potential power source for the experimental flight of the BSTS for the SDI program. In parallel with the MITG development, DOE is continuing its efforts to improve thermoelectric conversion efficiencies, including silicon germanium optimization, electrical contacting, evaluation of materials properties, degradation mechanisms, and material interactions.

To respond to future RTG delivery requirements, it is essential that DOE not only maintain a viable heat source production capability within its laboratory structure but also continue those efforts necessary to improve

heat source safety, improve production efficiency to reduce heat source costs, and continue work in long-lead areas. In FY 1987, the Mound Laboratory (Mound) near Miamisburg, Ohio, must begin the facility and tooling modifications for the assembly and testing of a planned terrestrial RTG delivery to DOD in late 1988. Also in 1987, Mound will start the design and safety qualification process for a small, sealed, heat source needed for the Special Applications program. We plan that the Oak Ridge National Laboratory (ORNL) will continue its heat source materials program, where improved processes and forming techniques show promise of lower unit cost for heat source iridium encapsulating material.

To meet our obligations to deliver low-wattage RTGs for terrestrial military missions, the Special Applications program will continue its efforts to develop and demonstrate the necessary technology. During 1987, an RTG demonstration system test will be continued to verify long-term performance predictions. Also, thermoelectric modules of primary and alternate designs will be tested under selected environmental conditions to support RTG performance predictions and reliability analyses.

FACILITIES

DOE and its contractors operate some of the most advanced and sophisticated nuclear test facilities in the world today for advanced power generation reactors, fuels, components, and materials. The facilities provide unique testing capabilities required for the development of safe, reliable, environmentally acceptable and efficient nuclear energy power sources that will be suitable for civilian power generation, space, and military

applications. These facilities are also used in the development of fusion technology; cooperative technology programs with other countries; non-nuclear energy programs such as coal, solar, and geothermal; and conducting tests for other Government and private sector organizations such as EPRI and the NRC.

These facilities include the LMR irradiation facilities--the ERB-II, the Transient Reactor Test (TREAT) facility, the Zero Power Plutonium Reactor (ZPPR), and support facilities at the Argonne National Laboratory near Idaho Falls, Idaho (ANL-West); the FFTF at the Hanford Engineering Development Laboratory (HEDL) near Richland, Washington; and the comprehensive non-nuclear liquid metal component test complex at the Energy Technology Engineering Center (ETEC) near Canoga Park, California. At the heart of the facility capability are experienced engineers, scientists, technicians, and operators. In recent years, the program has markedly improved the efficiency of its facilities. Non-essential facilities have been shut down and operations of remaining facilities have been improved. This effort is continuing in order to assure that this essential activity is carried on at the lowest possible cost.

The accomplishments and activities of our facilities and test programs are significant and include: (1) the FFTF has achieved a world record for continuous operation of an LMR at full power (101 days), demonstrating the outstanding reliability of LMR's; (2) fuel performance in the FFTF has gone well beyond the burnup goal of 80,000 megawatt days per metric ton; (3) successful testing in the FFTF of inherent safety features and advanced control concepts; (4) the recent successful completion of a loss-of-flow

without reactor scram test from 100 percent power in the EBR-II, which further attests to the passive safety capability of liquid metal cooled reactors; and (5) testing at ETEC is currently making significant contributions to LMR designs resulting from their natural circulation tests, advanced shutdown heat removal tests, and performance testing of advanced steam generators. Continued operation of FFTF, EBR-II, and ETEC continues to contribute to U.S. liquid metal reactor operating experience.

In FY 1987, the facilities will continue to support the changing civilian, military and space nuclear power requirements. Civilian advanced reactor concepts will require special tests for evaluation of fuels performance and reactor dynamics. Irradiation testing is assuming a more critical position in analysis of materials and fuel performance for military and space reactor applications.

The test programs planned for FY 1987 include reactor safety and fuel performance and component testing for advanced reactor concepts, irradiation of candidate core materials for space reactor use, irradiation of SP-100 fuel and cladding, run-beyond-cladding breach, operational transient testing under the joint United States/Japan Cooperative Program, irradiation of material specimens for the United States and Japan, and fusion programs and tests supporting reactor plant simplifications and cost reduction features.

The Department plans to evaluate the current methods by which users share in facility costs. Alternative cost-sharing approaches will be evaluated for partial implementation in FY 1987, with fuller implementation planned

for FY 1988, if practical. Facility operations are directed toward conducting required tests to support and verify advances in fuels, core systems, materials, safety, components, and instrumentation and control systems to meet civilian, defense, and space nuclear energy requirements.

WATER COOLED BREEDER REACTOR TECHNOLOGY

One of the variations of advanced nuclear technology is the use of a uranium-233/thorium fuel cycle. The Water Cooled Breeder Reactor program has the mission of developing technology that will significantly improve the efficiency of utilizing nuclear fuel resources. The specific objective is to prove that fuel breeding can be achieved in a light-water reactor using the uranium-233/thorium fuel system. The focus of program efforts in FY 1987 will be to complete evaluation of the light-water breeder core removed from the Shippingport Atomic Power Station to verify breeding, thereby bringing this project to its planned conclusion in FY 1987.

REMEDIAL ACTION AND WASTE TECHNOLOGY

The objectives of the Remedial Action and Waste Technology Program are to treat or stabilize radioactive wastes and perform decontamination and decommissioning at contaminated DOE and legislatively-directed non-government facilities and sites; help facilitate development of a reliable national system for managing low-level radioactive wastes; and develop acceptable technologies for the treatment and immobilization of nuclear wastes. Successful execution of this program is a key part of the Department's commmitment to continue to protect public health and safety

and to assure a safe and clean environment in connection with its activities.

The major Remedial Action and Waste Technology activities are: (1) the Formerly Utilized Sites Remedial Action Project (FUSRAP); (2) remedial action at Grand Junction, Colorado (Public Law 92-314 as amended); (3) the Uranium Mill Tailings Remedial Action Project (UMTRAP) for inactive uranium mill tailing sites (Public Law 95-604); (4) the Surplus Facilities Management Program (SFMP), for certain radioactively contaminated DOE facilities declared surplus and resulting principally from civilian nuclear energy programs; (5) demonstration of the solidification of high-level radioactive wastes at West Valley, New York, for final disposal (Public Law 96-368); (6) technical assistance to States and regions to assist them in developing new capacities for the disposal of low-level radioactive waste, in accordance with Public Law 96-573, the Low-Level Radioactive Waste Policy Act, and Public Law 99-240, the recently enacted amendments to this legislation; (7) development of nuclear waste treatment processes and waste forms suitable for transportation, storage, and ultimate disposal in a geologic repository; and (8) civilian byproducts utilization and applications with primary emphasis on food irradiation.

The requested funds for the Remedial Action and Waste Technology Program are distributed among the program elements as indicated in the following table.

Program Element	--($ in Millions)-- FY 1986 Estimate	FY 1987 Request
Remedial Action and Waste Technology		
Formerly Utilized Sites	$ 18.9	$ 25.6
Grand Junction	0.9	0.8
Uranium Mill Tailings	91.3	126.0
Surplus Facilities	39.9	56.4
West Valley	61.6	79.0
Low-Level Waste	4.6	4.0
Waste Treatment	6.2	0
Byproducts Utilization	4.8	0
Program Direction	1.8	2.3
Total	$230.0	$294.1

This increase in our FY 1987 funding request is consistent with prior year projections as we move from largely planning and engineering activities into the execution phases of major projects in the next 3 years. In light of fiscal constraints, this increase is less than planned, achieved through a stretch-out of the UMTRA program discussed in more detail below.

FORMERLY UTILIZED SITES REMEDIAL ACTION PROJECT

FUSRAP provides for remedial actions at former nuclear processing facilities which became radioactively contaminated as a result of former Manhattan Engineer District or Atomic Energy Commission (MED/AEC) activities and which have not been decontaminated sufficiently to meet current public health and safety guidelines. FUSRAP also includes certain contaminated sites specifically assigned to DOE by Congress for remedial action.

To remedy the situation at these contaminated sites, either the contaminated material will be stabilized in place, with restrictions placed

on the use of the site, or the contamination will be removed and disposed of at another location. Authority currently exists, derived from the Atomic Energy Act of 1954, for conducting remedial actions at 24 sites, based on a review of the involvement of the Department's predecessor agencies in activities at these sites. In 1985, this review process led to the addition, by the Department, of the following 4 sites (included in the total of 24 cited above) to the project: (1) former Bridgeport Brass Company, now a General Motors property (Adrian, Michigan); (2) former Bridgeport Brass Company, now Seymour Wire Specialty (Seymour, Connecticut); (3) National Guard Armory (Chicago, Illinois); and (4) former Metal Hydrides, Incorporated, now Ventron Division of Thiokol Chemical (Beverly, Massachusetts). Review of other sites involved in past activities of the Department's predecessors is continuing and is scheduled to be completed in 1987. This review may result in the addition of other sites to the program.

Congress added four sites in the FY 1984 Energy and Water Development Appropriations Act (Public Law 98-50), with direction to initiate a decontamination research and development project at these sites as a priority action. In the FY 1985 Energy and Water Development Appropriations Act (Public Law 98-360), Congress directed DOE to acquire the former St. Louis Airport site and use it to dispose of waste from cleanup of the nearby Latty Avenue site and vicinity properties. Congressional and Departmental additions bring the total number of sites in the project to 29.

The Department's Oak Ridge Operations Office has the lead role in implementing the Formerly Utilized Sites Remedial Action Project.

In FY 1985, the cleanup of the contaminated central drainage ditch leading from DOE-owned Niagara Falls Storage Site at Lewiston, New York, was completed for a distance of about 1 1/2 miles. In FY 1986, the Department expects to complete cleanup work at the remaining four contaminated properties near this site. Work will be completed on the installation of an interim cap on the waste storage area, about 9 months later than originally planned. This delay was due to technical problems in transferring the radium-contaminated residues from a concrete tower to a storage location and in treating large quantities of impounded water to meet stringent State standards for discharge. Other remedial actions at this site are described under the Surplus Facilities Management Program.

The Department is planning to complete the remedial actions at the Middlesex Landfill in New Jersey in FY 1986 that were about 50 percent completed in FY 1984. No cleanup work was done on this site in FY 1985. This is about 21 months later than originally planned, due to a large increase in the estimated volume of contamination and the higher priority assigned to the Maywood, New Jersey, remedial action.

Decontamination actions begun in FY 1984 and continued in FY 1985 are underway in FY 1986 at Maywood, New Jersey; Wayne, New Jersey; and Colonie, New York. The general approach to these projects is to give priority to the cleanup of contaminated residential properties and to store the waste temporarily on each processing and storage site. The cleanup of

residential properties in Maywood, contaminated with material from the Stepan Chemical Company site, was completed in FY 1985, along with some residential properties found to be contaminated from the Stepan site in the adjacent town of Lodi. The contamination from the Stepan site has been found to be more extensive, extending into Lodi and under New Jersey Route 17. In FY 1986, cleanup of one Maywood commercial property continues. Extensive characterization of the contaminated areas and engineering for further remedial actions will be completed. The waste from this site is being stored on an 11.7 acre part of the Stepan Company property at Maywood which Stepan donated to DOE in 1985 along with $580,000. The storage pile was expanded in 1985 and modified to meet State requirements. The Department recently completed a study of options for permanent disposition of the more than 270,000 cubic yards of waste. Removal of all the waste to a new disposal site in New Jersey is the preferred option because on-site stabilization that meets the Environmental Protection Agency (EPA) standard for durability requires relocating the existing chemical plant and would be more costly. Removal of the waste will also avoid the socioeconomic impacts of locating a disposal site in a densely populated area.

At Wayne, New Jersey, the cleanup of a ball field and a bus yard was completed in FY 1985, interim stabilization of the waste on site was begun, and onsite monitoring wells were installed. In FY 1986, about one-third of the cleanup of Sheffield Brook and cleanup of residential properties bordering the brook will be completed. Modifications are being made to the site so that wastes can be stored on the site temporarily. The site is

considered unsuitable for permanent stabilization because of ground water flow. The State of New Jersey has been requested to nominate candidate locations in the State for DOE to establish a site for disposal of the estimated 50,000 cubic yards of waste at Wayne, as well as the estimated 360,000 cubic yards of FUSRAP waste at Middlesex and Maywood.

At Colonie, New York, DOE acquired the NL Industries site as a donation in February 1984, along with two adjacent parcels owned by the Niagara Mohawk Power Company that have waste buried on them. Radiological surveys of a total of 130 vicinity properties have been completed through FY 1985, and of these, 54 properties need remedial action. About 90 to 100 additional properties remain to be surveyed. Cleanup of 35 properties was completed by October 1985 (11 in FY 1984 and 24 in FY 1985) and all remaining properties will be completed by October 1987. The contaminated soil is being temporarily stored inside the plant. We have completed a study of options for the permanent disposition of the more than 30,000 cubic yards of waste. Removal of the waste to a new disposal site is the preferred option because removal can be completed at lower cost than on-site stabilization and avoids the potential impacts of locating the disposal site in a densely populated area. The State has been requested to nominate candidate locations for a DOE disposal site in New York. In FY 1986, DOE will remove the radioisotope sources from the plant previously used for inspection work as well as hazardous chemicals in the plant.

At Hazelwood, Missouri, DOE has arranged with the site owner, Futura Chemicals Company, to use a part of the site for storage of contaminated soil. Cleanup of a portion of Latty Avenue, adjacent to the Hazelwood

site, was initiated in FY 1984 and was completed in FY 1985. Border areas on the site were cleaned up to prevent recontamination of Latty Avenue, and fencing was installed around the site. Radiological surveys of the vicinity properties were performed in FY 1985, and a survey of the developed part of the Latty Avenue site will be started in FY 1986. Cleanup activities on the remaining vicinity properties will not be started until the waste can be moved to the St. Louis Airport Disposal site. The City of St. Louis, Missouri, is considering the terms of transfer of the former St. Louis Airport Storage site to the Department for use in disposing of the estimated 60,000 cubic yards of waste from the Hazelwood site and vicinity properties, as required by language contained in the report that accompanied the FY 1985 Energy and Water Development Appropriations Act (Public Law 99-360). In FY 1985, DOE installed a 300-foot rock wall (gabion) at the Coldwater Creek bank of the Airport site to prevent erosion from spreading contamination into Coldwater Creek. In FY 1986, further site characterization (radiologic and geologic) work will be started and this work will be completed in FY 1987. Preliminary design work, initiated in FY 1986, will be completed in FY 1987.

A revision to the FUSRAP Project Plan was completed in FY 1985. A preliminary total cost estimate of $675 million has been made for the FUSRAP scope, consisting of 25 sites, based on completion of all the work by the year 2001. The Plan will be updated in FY 1986 to include the four additional sites added by the Department in FY 1985.

GRAND JUNCTION REMEDIAL ACTION PROJECT

Under Title II of Public Law 92-314, Congress authorized financial assistance to the State of Colorado to limit radiation exposure resulting from the use of uranium mill tailings for construction purposes in Grand Junction, Colorado. This State and Federal cooperative effort is administered by the Colorado Department of Health through DOE's Grand Junction Project Office. The remedial action provides for removal of uranium mill tailings from the premises of an estimated 583 structures where concentrations of radioactive radon and its decay products exceed guidelines established by the Surgeon General. Public Law 95-236 extended the time, which has now expired, for property owners to apply for inclusion and also increased the authorized funding for the program. Federal funds cover 75 percent of the program costs, with the State providing the balance. Contingent upon the availability of adequate funding from the State of Colorado, the remedial action is expected to be completed in FY 1987, with final radiological verification to be completed in FY 1988.

At the end of FY 1985, work had been undertaken on 546 structures. In FY 1986, radiological assessments will be continued, engineering on all properties will be completed, and remedial actions will be initiated at 22 additional structures, including 19 residences, ? commercial establishments, and 1 church. In FY 1987, work is scheduled to be undertaken on 15 properties, including 6 commercial structures, bringing the total number of properties completed to 583.

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT (UMTRAP)

UMTRAP is responsible for conducting remedial action at 24 former uranium ore processing sites and several thousand contaminated vicinity properties, as mandated by Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978. Nine of the sites are designated as high priority, six as medium priority, and nine as low priority. The Act provides authority for remedial action by the Department for a period of 7 years following promulgation of EPA standards, which occurred in March 1983.

The Department is proposing to extend the 7-year authorization period until the end of FY 1993, consistent with the recommendation to extend the duration of the project made by the House Appropriation Committee in House Report No. 99-195 accompanying the FY 1986 Energy and Water Development Appropriations Act (Public Law 99-141). The FY 1987 budget request identifies resource requirements to meet this extended schedule. The proposed extension takes into consideration the actual project experience gained in performing remedial action at several processing sites and many vicinity properties. Project plans have been revised to reflect this experience, and are based on the following key assumptions: (1) 4,535 of the 8,156 designated vicinity properties will actually require clean up in accordance with EPA standards; and (2) seven of the tailings piles (i.e., Durango, Colorado; Grand Junction, Colorado; Gunnison, Colorado; Rifle, Colorado; Bowman, North Dakota; Lakeview, Oregon; and Salt Lake City, Utah) will be relocated.

The program strategy is to focus near-term program activities on the higher priority sites and on vicinity properties. Remedial actions are being conducted in accordance with cooperative agreements negotiated with the affected States and Indian tribes. Federal funds cover 90 percent of the remedial action costs (100 percent for the sites on Indian lands), and the States provide funding for the remaining 10 percent. The type of remedial action for the processing sites will be to stabilize the mill tailings in place, where possible, or to remove them to a new disposal site. In either case, the final disposal sites will be Federally owned and maintained under NRC licenses. Engineering plans and environmental documents are prepared for each site cleanup and disposal operation. Concurrence by the NRC and the affected State or Indian tribe are required for the remedial action plan at each site. The project also involves the cleanup of an estimated 4,535 contaminated vicinity properties mainly in the Grand Junction area but not covered by the Grand Junction Remedial Action Project. The Department's Albuquerque (New Mexico) Operations Office has the field management responsibility for implementing UMTRAP.

Specific accomplishments in FY 1985 included the completion of 90 percent of the remedial action at Canonsburg, Pennsylvania, and initiation of remedial action at Salt Lake City, Utah; and Shiprock, New Mexico. The implementation of the remedial action at the Salt Lake City processing site has been assigned to the State of Utah. The approach at this site is to relocate the tailings to a site near Clive, Utah. Cleanup continued at high-priority vicinity properties near the sites at Canonsburg, Pennsylvania; Salt Lake City, Utah; Grand Junction, Colorado; and Edgemont,

South Dakota; and started at Shiprock, New Mexico; Riverton, Wyoming; and Durango, Colorado.

During FY 1986, work is underway or planned at five processing sites. The Canonsburg project will be completed early in the fiscal year. The work at Salt Lake City will be brought to an estimated 70 percent of completion, and the work at Shiprock will be 90 percent completed. Onsite work will be started at the processing sites at Tuba City, Arizona, and Lakeview, Oregon. Over 400 vicinity properties located at several high-priority sites will also be decontaminated.

During FY 1987, remedial action will be underway at 9 processing sites and 900 vicinity properties. The work at Shiprock, New Mexico, and Salt Lake City, Utah, will be completed. Work will continue at Tuba City, Arizona, and Lakeview, Oregon. Processing site remedial action will be started at Durango, Gunnison and Grand Junction, Colorado; Riverton, Wyoming; Ambrosia Lake, New Mexico; and Mexican Hat, Utah.

SURPLUS FACILITIES MANAGEMENT PROGRAM

This program provides for the safe management and disposition of certain surplus radioactively contaminated DOE-owned facilities from nuclear energy development activities. The decontaminated facilities and sites are to be returned to other productive use, where appropriate. (Similar actions at defense-related facilities are separately budgeted as Atomic Energy Defense Activities.) The facilities are grouped into 35 projects under this activity. This number increases by one for FY 1987 because the Department

will assume the responsibility for decommissioning the Power Burst Facility in Idaho, formerly supported by the NRC. A long-range plan was completed in April 1985 to establish the overall schedule and priorities for sites currently in the surplus inventory. Priorities are established and work schedules are developed through analysis of public health and safety, legal, economic, and work continuity factors for each site. The Department's Richland (Washington) Operations Office has the lead role in implementing this program.

In FY 1985, the major onsite cleanup and upgrading of the interim storage cell was continued at the Niagara Falls Storage Site in Lewiston, New York. The remainder of the 4,000 cubic yards of residue stored in a 160-foot tower were transferred through a 3/4-mile pipeline and were excavated from the tower to a low concrete building at the waste storage area. The tower was demolished and the contaminated rubble was moved to the storage cell. A thick clay cap with a design life of greater than 25 years is being placed over the wastes to minimize water infiltration. Installation of this interim cap is scheduled for completion by the end of FY 1986. A Final Environmental Impact Statement (EIS) on the long-term management for this site was issued earlier this month. In FY 1987, only surveillance and maintenance of the Lewiston site is planned. Since all offsite and onsite contamination will have been consolidated into the monitored and controlled storage cell, there will be no urgency from a health viewpoint to proceed with implementation of the long-term management option. This work will be deferred to use available funds for higher priority work.

Work on the decontamination of plutonium-contaminated facilities at Mound Laboratories will be continued in FY 1986 and FY 1987 and completed in FY 1988. This 11-year project was begun in 1978 and will continue through planned completion as a high priority.

Decommissioning of the Shippingport Atomic Power Station is another major DOE project. Following defueling of the reactor at the end of FY 1984, physical dismantling of the plant began in FY 1985. Preparations for removal of major components were begun, and some noncontaminated buildings were demolished. Dismantling of portions of the plant will continue in 1986 and 1987 and is scheduled to be completed in FY 1990. Preparation for the removal of the reactor pressure vessel will begin in FY 1987; the vessel is scheduled to be barged to the Department's Hanford Reservation near Richland, Washington, for disposal in FY 1989. The Department is cooperating with the NRC and EPRI in obtaining samples and providing plant components to study aging effects. The Department is participating in a Nuclear Energy Agency-sponsored international exchange of decommissioning technology, which includes Shippingport, West Valley, and eight significant projects in other member countries.

In FY 1985, the Department continued interim site maintenance and monitoring as well as engineering and planning for the Weldon Spring Site Remedial Action Project in Missouri, a major DOE project. In addition, a Request for Proposals was issued for the remedial action project management contractor and a radiological characterization report for the Weldon Spring Quarry was completed. In 1986, field work for characterization (radiological, chemical and geological) of the Chemical Plant area will be

initiated and will continue into FY 1987. Preparation of a draft EIS to be issued in 1986 is underway. The Department's preferred alternative is stabilization of the wastes on site in a disposal cell designed to meet EPA requirements for the stabilization of uranium mill tailings. The project management contractor has been selected and a DOE onsite project office will be established in FY 1986. Conceptual design engineering by the project management contractor will begin in FY 1986 and continue through 1987. The Final EIS and Record of Decision will be issued in FY 1987. Contractors will be mobilized on the site, using local area labor, and remedial action will be started in FY 1987. We estimate that remedial actions at the Weldon Spring site will be completed in FY 1995 and a final report issued by the end of FY 1996.

As previously mentioned, a new project will be added to the SFMP in FY 1987, decommissioning of the Power Burst Facility in Idaho. Current plans are to place the facility into an interim safe storage condition by initiating stabilization and fuel removal to dry storage in FY 1987. The facility is expected to be in a safe storage condition by the fourth quarter of FY 1988 or the first quarter of FY 1989. This condition will minimize surveillance and maintenance costs until funds are available for complete decommissioning, about 1993.

Other activities in FY 1987 will include continuation of site and facility disposition projects at Monticello, Utah; Santa Susana, California; the Argonne National Laboratory (ANL) in Illinois; the Oak Ridge National Laboratory in Tennessee; the Idaho National Engineering Laboratory in Idaho; and the Los Alamos National Laboratory (LANL) in New Mexico.

Decommissioning of the reactor at the Center for Energy and Environment Research (CEER) in Puerto Rico will begin in FY 1986. At Monticello, Utah, mill tailings will be removed from 12 residential properties, leaving only about 6 properties to be completed in FY 1988. The environmental assessment will be completed for the Monticello mill site in FY 1986 and work on the site will start in FY 1987. Decontamination of surplus facilities at the 350 Area of the ANL-East complex will be completed in FY 1986 and preliminary activities started for the decommissioning of the Experimental Boiling Water Reactor.

WEST VALLEY DEMONSTRATION PROJECT

The objective of the West Valley Demonstration Project is to demonstrate the solidification process for disposal of high-level liquid nuclear wastes under the provisions of Public Law 96-368, the West Valley Demonstration Project Act. An integrated production-scale development and demonstration project for treating high-level liquid nuclear wastes is being carried out at the Western New York Nuclear Service Center, near West Valley.

Major activities being performed as part of this project include: (1) demonstration required to prepare existing facilities and equipment to accommodate the solidification project; (2) removal of wastes from underground storage tanks; (3) development, design, construction, and operation of systems and necessary supporting facilities for the solidification of the wastes; (4) acquisition of containers for the permanent disposal of the solidified waste; (5) temporary storage and transportation of the solidified waste to an appropriate Federal repository

for permanent disposal; (6) decontamination and decommissioning of the waste tanks, facilities, hardware, and material used in carrying out the project; and (7) disposal of low-level and transuranic wastes produced from project activities.

Project activities in FY 1985 led to the accomplishment of the most challenging goal of the Project to date, the start of verification testing of major subsystems of the Vitrification System. Individual testing of subsystems was completed in FY 1985 allowing for the start of integrated testing of all major portions of the Vitrification System. Other accomplishments during this period included completion of cleanup of the first of several former reprocessing cells and initial testing of the overall system that will solidify low-level liquid wastes.

The design of all systems necessary to convert the Component Test Stand into the final shielded Vitrification Facility is now underway. Radioactive testing in a pilot-scale vitrification system using the West Valley formula for the high-level waste form will begin later this year to support the development of operational procedures for the West Valley Vitrification Facility. The final design of the Supernatant Treatment System to pretreat and reduce the volume of the liquid high-level waste will be completed as well as the civil construction and procurement activities for this system. Installation of equipment for treating low-level liquid wastes before they are solidified in cement will be completed in FY 1986. Decontamination of needed shielded cells will be continued to meet project needs.

In FY 1987, testing of the Vitrification System will concentrate on validation of process control techniques. In parallel, structural aspects of the conversion of the Component Test Stand into the final Vitrification Facility will be completed. The Supernatant Treatment System will be installed and testing completed leading to the start of supernatant processing in mid-FY 1987. The supernate now stored in underground tanks represents nearly 90 percent of the volume and 50 percent of the radioactivity of the stored liquid waste. The separated radioactive material will be stored and later blended with the sludge from the storage tanks and glass formers prior to being fed into the melter in the Vitrification Facility. The Liquid Waste Treatment System will be completed early in the year and used to treat low-level liquid wastes resulting from operation of the Supernatant Treatment System. Decontamination of needed hot cells will continue.

LOW-LEVEL WASTE MANAGEMENT ACTIVITIES

The Low-Level Waste Program provides assistance to States and regions in developing new capacity for the disposal of low-level radioactive waste, in accordance with Public Law 99-240, the Low-Level Radioactive Waste Policy Amendments Act of 1985, enacted on January 15, 1986. This legislation has assigned the individual States the responsibility for the disposal of low-level wastes generated within their borders, with the exception of waste generated as a result of certain Federal activities and civilian low-level waste exceeding the limits established by the NRC for Class C low-level waste. The formation of regional compacts to carry out this responsibility

is encouraged by the Act. The goal of the Department's Low-Level Waste program is to assist States and regions in the development of an effective nationwide low-level waste management system. The Act has also assigned several new responsibilities to the Department in addition to providing assistance to States and compact regions.

During FY 1986, the Low-Level Waste Program will conduct the activities required in the Act and will focus primarily on meeting the generic technical needs of the States and compact regions as they work to select sites and develop new disposal facilities. Specifically, the Department plans to concentrate on assisting States and regions in evaluating alternative disposal technologies to those currently in practice at the currently operating sites in Washington, South Carolina, and Nevada. The program will support the continued correction of problems and stabilization efforts at disposal sites no longer in operation and will continue to provide an evaluation of innovative waste treatment methods to the private sector. DOE expects to finish development of the procedures that will be used to evaluate proposals for transfer of closed low-level waste sites to the Department under Section 151 of the Nuclear Waste Policy Act of 1982.

In FY 1987, the Low-Level Waste Program will continue to provide technical assistance to States and regions to support the selection and development of new low-level disposal facilities; support the correction of problems and stabilization at existing disposal sites; and complete an assessment of advanced, innovative methods for the treatment and disposal of low-level waste. The report identifying options for the Congress on disposing of greater-than-Class C low-level wastes will be completed by January 1987.

WASTE TREATMENT

The goal of the Waste Treatment Program over the past 5 years has been to develop and transfer technologies for the treatment and immobilization of nuclear wastes in forms acceptable for transportation, storage, and disposal. Efforts have been focused on determining the long-term reliability and maintaining the ability of a prototypical high-level waste treatment system, on testing and selecting acceptable high-level waste forms for storage or disposal, and on transferring treatment technologies to specific Departmental waste management programs such as the West Valley Demonstration Project.

In FY 1986 we will complete the second year of our efforts to determine the operational reliability, safety, and process control flexibility of the ceramic melter system for solidification of high-level radioactive wastes and continue collaborative programs with the Federal Republic of Germany and Japan on testing of a radioactive vitrification system.

In FY 1987, radioactive testing of the high-level waste vitrification system at the Pacific Northwest Laboratory will be stopped unless individual users have a need for and fund additional research and development work. Reports on R&D results obtained in FY 1986 will be completed.

BYPRODUCTS UTILIZATION

In the FY 1986 Energy and Water Development Appropriations Act (Public Law 99-141), Congress provided resources for a civilian byproducts utilization program with a primary emphasis on food irradiation. We have proceeded--in cooperation with States, other Federal agencies, and private sector organizations--to develop plans and designs for establishing agricultural commodity irradiators in States selected on the basis of their needs and proximity to major agricultural production and processing centers. In anticipation of possible widespread use of food processing with irradiation, this program also focuses on developing an adequate U.S. based supply of radiation sources. Funding from the private sector will be sought for completion of these projects in future years, including FY 1987.

URANIUM ENRICHMENT ACTIVITIES

The Department's FY 1987 budget request for the Uranium Enrichment program is approximately $1.05 billion in budget authority, which will be fully offset by $1.29 billion in projected revenues. In addition, DOE proposes to return $235 million to the Treasury as a part of the repayment of prior Government investment in the uranium enrichment enterprise.

The funds requested are distributed among the major elements of the program as tabulated on the following page.

Program Element	--($ in Millions)-- FY 1986 Estimate	FY 1987 Request
Uranium Enrichment Activities		
Gaseous Diffusion Operations & Support	$1,075.0	$ 992.6
Atomic Vapor Laser Isotope Separation	127.0	50.0
Gas Centrifuge Program Closeout/Activities	344.4	4.0
Program Direction	4.0	4.8
Subtotal	1,550.4	1,051.4
Payback to Treasury	0*	235.0
Total	1,550.4	1,286.4
Uranium Enrichment Revenues	-1,360.6	-1,286.4
Net Appropriation	189.8	0

* Revenues in excess of outlays of approximately $110 million will accrue to the Treasury in FY 1986.

The next 2 years will be a key time period for the uranium enrichment enterprise. During this period the program restructuring which began in 1984 will continue. In the last 2 fiscal years, significant progress has been made in redirecting the enterprise to help assure its competitiveness and long-term viability in the international marketplace. Supply and demand have been stabilized by issuing the Utility Services (US) contracts and by very successfully converting existing customers to the new contracts. Having defined the customer demand that must be met through the conversions to the US contracts, the Department then developed appropriate production and R&D strategies to meet that demand and announced those decisions in June 1985.

Through revision of the Uranium Enrichment Services Criteria, the ground rules under which the enterprise will operate in the future will be

refined. The Department will initiate payments to the Treasury in recovery of prior unrecovered costs.

A new initiative now under review is an effort to transfer future development and ultimate deployment of the AVLIS technology to the private sector. The areas in which the private sector can most beneficially be involved in the enterprise will be evaluated. At a minimum, it is hoped that the private sector will be interested in deploying the AVLIS technology. This advanced method of enriching uranium holds significant technical and economic potential for the United States and should provide the type of challenge which the private sector has demonstrated its capability to meet. In that light, the Department will initiate later this year an industrial access program to allow qualified U.S. firms to become familiar with the AVLIS technology so that there is an assured industrial base to deploy the technology in the future.

We believe the prospects for a bright future for uranium enrichment in the United States continue to improve. It is clear that the changes made the last few years were necessary. The enterprise is becoming much more cost competitive in operating the existing gaseous diffusion plants and is continuing the development of the world's most advanced enrichment technology for the future. However, there is more to be done. In FY 1987, the Department will develop the institutional framework that will assure that the Nation continues to have a reliable supply of enrichment services for the long term. We must continue to pursue vigorously a restructuring of the enterprise and the involvement of the private sector to assure that

the optimum benefits of the strategy on which we embarked several years ago are achieved. A brief review of the elements of that strategy follows.

OBJECTIVES

Our primary objective is to retain a competitive, financially healthy uranium enrichment supply capability in the U.S. for the long term consistent with the Atomic Energy Act, other legal requirements, and the interests of the Nation.

The major goals which have been established for the U.S. uranium enrichment enterprise, as articulated in the June 1985 strategy, include:

- to bring supply and demand of DOE-origin enriched uranium into balance;
- to offer reliable customer services;
- to offer competitive prices;
- to capture uncommitted market consistent with financial interests;
- to minimize the cost of operating existing enrichment plants;
- to retain the U.S. leadership in advanced technology and deploy as appropriate to meet business objectives; and
- to adopt a more businesslike institutional structure.

Important progress has been made toward achieving these goals. A summary of some of the more significant accomplishments during the past 2 years follows.

BRING SUPPLY AND DEMAND INTO BALANCE

The US contracts, introduced in January 1984, were a major step which have enabled the enrichment enterprise to compete more effectively in the international marketplace. About 90 percent of DOE customers converted to these contracts. They have brought stability to our projected sales base and corresponding revenues. They have permitted DOE customers to reduce enriched and natural uranium inventories, and produced a more orderly market serving the nuclear fuel cycle.

Subsequently, representatives of the uranium mining industry brought suit against DOE based on the procedures which were used to introduce the terms of the new contract form. Litigation concerning the US enrichment contract is proceeding in both the U.S. District Court for the District of Colorado and in the U.S. Court of Appeals for the Tenth Circuit. DOE has appealed the judgment of the district court in which the court ruled that the US contract was null and void.

OFFER RELIABLE CUSTOMER SERVICES

Reliability of supply is a term we hope will become synonymous with U.S.-supplied enrichment goods and services. We strive continually to offer the world's most reliable enrichment services and to respond quickly to changes in the marketplace. We believe this is a significant factor in utility decisions, both here and abroad, to contract with DOE for their enrichment services.

OFFER COMPETITIVE PRICES

A crucial element of our competitive strategy is the approach to pricing. The market is extremely price sensitive and DOE prices must be competitive. The key to the survival of the U.S. uranium enrichment business is to get near-term prices down into the competitive range by aggressively reducing costs.

The price for US contract holders in 1985 was $135 per separative work unit (SWU). In announcing the June 5, 1985, enrichment program decisions, Secretary Herrington pointed out that maintaining the DOE price at uncompetitive levels was, in effect, a going out of business strategy. On October 1, 1985, a price reduction to $125 per SWU became effective. This price is still significantly higher than those currently offered by competitors. Accordingly, DOE has announced its plans to continue its price reduction policy by offering a FY 1987 base price of $119 per SWU effective October 1, 1986.

This declining pricing pattern for the U.S. adds credibility to plans for even lower prices in the future. The results of not following a competitive pricing strategy would have serious impact on the enterprise. It is estimated that DOE would lose about $7 billion in revenues between now ard the year 2000 if it were to keep prices at the current $125 per SWU level. Thus, our pricing policy is crucial to the competitive strategy.

CAPTURE UNCOMMITTED MARKET

During the past year, we have taken strong actions to revitalize this country's uranium enrichment enterprise. Most notably, through several creative marketing initiatives, we were able to increase our share of the free world enrichment market from 46 percent in 1985 to 53 percent in 1990.

In 1985, there remained 6 million SWU's of uncommitted sales opportunities with DOE enrichment customers available from FY 1987 through FY 1990. During this period, DOE has excess production capacity that could produce SWU's at low marginal costs. To allow its customers to benefit from this capability, in April 1985, DOE offered an incentive price of $90 per SWU to customers with uncommitted sales in FY 1987 through FY 1990. This incentive pricing offer proved very successful--nearly 87 percent of DOE customers with uncommitted requirements accepted the incentive price proposal. As a result, DOE sales for FY 1987 through FY 1990 time period increased by 14 percent, or over 5 million SWU's.

In 1986, we have attempted to solidify and increase our market share for the period 1991-1995. In light of our previously successful pricing effort, we made a new incentive pricing offer to our customers. In return for customer commitments to purchase 100 percent of their enrichment requirements from DOE in the 5-year period from FY 1991 to FY 1995, DOE proposed a price of about $85 per SWU for the remaining 30 percent fraction of their enrichment requirements. Under US contracts, 70 percent of the customers' enrichment requirements would be priced at the DOE base price. We have had a very favorable response to our incentive price offer. Those

customers who took advantage of this highly attractive offer represent about 75 percent of DOE's uncommitted sales opportunities in the FY 1991-1995 time period.

We plan to continue aggressive market initiatives in the future to increase DOE's market and revenues, discourage competitor investment in new capacity, improve the U.S. trade balance, prevent competitor penetration of DOE's market share, and effectively utilize excess DOE production capacity. In addition, a larger sales volume to DOE will result in lower unit production costs which could be passed along to all customers in the form of lower prices.

MINIMIZE COSTS OF EXISTING PLANT OPERATIONS

Because minimizing the cost of existing plant operations is key to near term DOE price competitiveness, Secretary Herrington decided in June 1985 to place the Oak Ridge (Tennessee) Gaseous Diffusion Plant in standby status at the earliest possible date. This major, near-term cost reduction decision followed extensive analysis that showed that about $250 million could be saved between FY 1986 and FY 1991 by taking that action. The Oak Ridge Gaseous Diffusion Plant has been in standby status since August 1985, and will remain in that condition with the DOE Office of Defense Programs providing the standby funding because of projected defense demands for enriched uranium in the outyears. If the standby funding is not provided, the plant will be shut down permanently. If the plant is permanently shut down, it will not be operable because critical components will no longer be maintained.

The costs of operating the Portsmouth and Paducah Gaseous Diffusion Plants (GDP's) were also reduced in FY 1985. New and innovative ways of operation, coupled with the use of lower cost unfirm power which is about 30 percent cheaper than firm power, improved the economics of operating the GDP's. Significant savings have been demonstrated through the use of low-cost evening, weekend, and offpeak seasonal power. It is planned to continue to take advantage of this lower cost, unfirm power to the maximum extent possible in the future.

Another strategically necessary but very difficult cost reduction decision was the termination of the GCEP project. After extensive analyses, the Department concluded that any GCEP completion scenario that required the outlay of significant amounts of additional capital was unjustifiable from an investment point of view. Simply put, the best GCEP scenarios resulted in production costs that were about equal to the production costs of the GDP's that are operating today, and all GCEP scenarios involved greater technical and economic risks than continued GDP operation.

Closeout of GCEP-related activities is proceeding well and DOE is working diligently to identify alternative uses for the GCEP equipment and facilities as well as other centrifuge facilities throughout the country.

RETAIN U.S. LEADERSHIP IN ADVANCED TECHNOLOGY

The U.S. currently enjoys a commanding lead in developing the world's most advanced enrichment technology, the AVLIS process. We plan to maintain

that lead to assure that, even when other countries decide to deploy AVLIS, the U.S. will have a more advanced, lower cost process on line.

The figures of merit that favored the selection of AVLIS over the Advanced Gas Centrifuge for further development clearly showed its greater potential for low cost and reliable production for the future. The AVLIS technology is less capital intensive, requires significantly less investment prior to a decision to deploy, has a lower estimated SWU cost, has greater potential for cost reductions through technology improvements, and is more adaptable to deployment in increments that can match the evolving needs of the enrichment marketplace.

In FY 1985, the one-half scale MARS separator was successfully integrated with the first phase of the Laser Demonstration Facility for enrichment tests. Test results will establish an experience base in the operation of large scale integrated hardware as well as calibrate the consistency between model prediction and measured enrichment performance. The near full scale Materials Handling Demonstration Module was operated continuously for over 100 hours, thereby establishing the initial key segment of materials handling technology for design and operation of a full-scale separator pod.

In FY 1986, these facilities will be used to demonstrate enrichment for extended periods of time and to demonstrate the materials handling capability of this subsystem. Attention will focus on resolution of issues identified by the Process Evaluation Board as being technically critical or having high economic leverage.

Ultimately, the successful deployment of AVLIS will depend in large measure on the existence of qualified industrial capability to carry the AVLIS technology out of the laboratory and into commercial operation. Accordingly, we will be instituting an industrial access program for AVLIS this year in an attempt to develop a knowledgeable industrial base for deployment.

RECOVERY OF PRIOR GOVERNMENT COSTS

The Government's outstanding investment will be recovered in a manner that will assure that commercial and military customers will continue to obtain competitively priced enrichment services. The Administration is committed to the recovery of appropriate Government costs over a reasonable period of time as required by the Atomic Energy Act. DOE will return to the U.S. Treasury, over a reasonable period of time, previously unrecouped and unrecovered costs associated with the provision of enrichment services to civilian customers. The outstanding Government investment will be reduced from $7.5 billion to approximately $3.5 billion by an amount equivalent to 60 percent of the GDP's that are no longer an earning asset and the entire GCEP, which never was and never will be an earning asset. These assets are not being used to provide enrichment services for the benefit of commercial customers. In addition, the outstanding investment will also be reduced by amounts equal to imputed interest charges after these assets were deemed to be "nonearning." These amounts are tabulated on the following page.

	($ in Millions)
Total Government Investment	$ 7,573
Less: 60% of GDP investment	1,200
GDP imputed interest	193
GCEP investment	2,589
GCEP imputed interest	110
Total Unrecovered Investment	$ 3,481

Imputed interest on the outstanding investment made prior to October 1, 1986, will be computed at an interest rate of 6.319 percent--the average of Treasury rates applicable in the years in which net increases in Government investment occurred, weighted by the dollar amount of these annual increases.

Payments to Treasury will be set for each fiscal year and the subsequent year through the annual budget process. The Department plans payments to the Treasury of $110 million in FY 1986 and $235 million in FY 1987.

MODIFICATION OF THE URANIUM ENRICHMENT SERVICES CRITERIA

One key action recently initiated by DOE is the proposed modification of the Uranium Enrichment Services Criteria. A Notice of Proposed Rulemaking was published in the Federal Register on January 29, 1986. The proposed Criteria modification addresses: (1) items that were questioned in the miners' lawsuit; (2) other aspects of the enterprise, including flexibility for future competitive actions; and (3) reiteration of the Administration's position opposing restrictions on the enrichment of foreign natural uranium.

Interested parties were invited to comment on the proposed Criteria as part of the rulemaking process, and approximately 60 different sets of written comments were received. DOE also held a public hearing on the proposed Criteria on March 18, 1986. Based on the comments we have received to date, DOE will soon publish an additional analysis regarding the recovery of prior Government costs in the Federal Register and request further public comments based on this supplemental information. Subsequent to the review and consideration of all comments received, DOE will submit the revised Criteria to Congress at least 45 days prior to their actual effective date pursuant to section 161.v. of the Atomic Energy Act of 1954, as amended. DOE hopes to complete this rulemaking process during 1986.

POTENTIAL PRIVATE SECTOR PARTICIPATION

The Department published a notice in the April 7, 1986, Federal Register that it was seeking expressions of interest from the private sector concerning potential participation in the Uranium Enrichment enterprise. This request for expressions of private sector interest is exploratory in nature. While our action is part of a broad Administration initiative to evaluate the transfer of certain Federal functions to the private sector, no decisions have been made by DOE regarding the sale of any uranium enrichment assets.

This completes my statement. I would be pleased to respond to any questions you may have at this time.

The CHAIRMAN. Thank you, very much, Mr. Secretary. Obviously, I have a whole list of questions and time will not permit all of them. I don't mean to indicate by my questions that I have no interest in the areas which are not covered by the questions that I ask today because many of them will be covered in the submissions.

Could you give the committee a better idea of your anticipated funding levels and schedule for establishing technical feasibility of Argonne's integral fast reactor concept?

Mr. VAUGHAN. Mr. Chairman, in the fiscal year 1987 budget, there are approximately $7 to $9 million in the program for specific efforts on that reactor, plus a large share of the supporting dollars for the operation of the EBR-2 reactor in Idaho.

The CHAIRMAN. If the predictions on improved safety fuel cycle costs and proliferation resistance prove correct on the IFR, what will be the next step in the development?

Mr. VAUGHAN. Mr. Chairman, as you know, we are carefully going through a series of tests designed to confirm the feasibility of various key features that have been advocated by Argonne for that concept. We would anticipate that near the end of 1988, most but not all of those aspects will have been pinned down one way or the other, and certainly some of the longer-term fuel behavior which is so critical should be achieved by 1989, or 1990 at the latest.

I think that by that time, depending on other work that goes in parallel, it should match our timetable for focusing down and proceeding with more detail design and potentially demonstration of the optimum advanced reactor concept.

The CHAIRMAN. At what level is HTGR research being funded in fiscal year 1986?

Mr. VAUGHAN. In fiscal year 1986, the level is approximately $32 million.

The CHAIRMAN. That is after the sequester?

Mr. VAUGHAN. That is after the sequester.

The CHAIRMAN. What is the proposed funding level for fiscal year 1987?

Mr. VAUGHAN. It may be a little bit less than that after the sequester, but it is not more than 3 or 4 percent less.

The CHAIRMAN. What is the proposed funding level for 1987?

Mr. VAUGHAN. The proposed funding level in 1987 is approximately $5 million on that effort, which is a noticeable reduction. That is one of the items that we feel compelled in the priorities, with the budget stringencies, to stretch out based on where we see the market.

The CHAIRMAN. What program elements will be terminated as a result of dropping funding?

Mr. VAUGHAN. Mr. Chairman, and not to be unresponsive, let me concentrate first on the key things we would hope to continue, because I believe the things that we would continue would not force the termination, per se, of any efforts, but simply the deferral of some.

We plan to concentrate in fiscal year 1987 on the key technical questions which could affect licenseability of that concept, the passive safety features, the licenseability of the overall core and plant,

the capability of the circulating system, and particularly to seek interfaces with NRC on the licenseability.

We think these key factors will enable us to determine whether it is prudent to continue the investment in that project.

The CHAIRMAN. I will make a comment, rather than a question. We have received here quite a lot of interest from the utility sector and some representations that the private sector is willing to move towards some cofunding, and it seems to me if that is true, it might change our sense of priorities with respect to expenditures.

Without pursuing that any further at this time, I want to move to another area that you touched on that is troublesome. I am almost afraid to go into it because of what it may reveal.

Your proposal in fiscal year 1987 budget for making annual payments to Treasury on the uranium enrichment debt is the issue that I would like to explore. The OMB concept, which sounds to me like one of the more clever uses of words in this town, is one in which they justify these payments by saying that you have a debt of $3.4 billion.

Let us look at this like you would a business. And I assume that really is where OMB is coming from; they want to make a business decision here.

Based on the program's funding history, Congress has given you, according to the utility's calculation, $350 million more than your revenues for the commercial part of your business over the last 15 years. Now, if a business had to borrow $350 million over 15 years to sustain its operations, its debt would be $350 million, wouldn't it?

Mr. VAUGHAN. Plus the interest.

The CHAIRMAN. Plus the interest. Now you say that your assets in uranium enrichment are worth $3.4 billion today. Is that correct?

Mr. VAUGHAN. That is correct. That is roughly the value of the assets which we believe are productive and useful.

The CHAIRMAN. If a company is worth $3.4 billion and owes $350 million, its debt is $350 million; is that not right? And its assets are $3.4 billion.

Mr. VAUGHAN. That is correct.

The CHAIRMAN. Now the clever OMB plan is to call your assets a debt and then OMB wants you to charge yourself interest on your assets like it was a debt. Using that kind of accounting, you will always be in debt from the OMB viewpoint, even after you have paid several billion dollars to the Treasury.

What worries me and I would say many of my colleagues is that this issue is more than just semantics. If your business gets saddled with this bogus debt, you have only two ways to pay it; you can sell this business, either in whole or in part, or you can raise your prices so much you can drive all of your business to foreign suppliers.

Either way, the United States goes out of the enrichment business.

I do not want to put you in the impossible position of either trying to convince us again that OMB's position makes any sense, or having you try to rationalize the administration's privitization policies. Can you simply answer me on one point?

Does not forming an enrichment corporation, like that described in Senator Domenici's legislation and setting a realistic and fair debt of $350 million a better plan than having no uranium enrichment business in the United States?

Mr. VAUGHAN. Mr. Chairman, when you put the question that way, if those were the only two choices, it is obvious that the former situation would be better than the latter. We believe that there is some value in recovering the Government's assets, most of which is inventories, and that recovery meets objective for deficit reduction. Very frankly, and secondly, we believe, as I testified here earlier this month, that the proposed quasi-Government corporation concept suggested in Senator Domenici's legislation is one of the concepts that merits evaluation for the future.

The CHAIRMAN. Mr. Vaughan, I don't really want to extend this discussion off into blind alleys or unconstructive detours. It reminds me a little bit of a proposal that might be made but hasn't been made, that we could sell off Yosemite and make money out of it. It is an asset. It has commercial value; in the hands of a commercial operator, it could become a money-maker, instead of us putting money into it in annual appropriations and maybe OMB would really like to see us sell that off, and they could be charging its asset value as a debt and requiring repayment to raise the fees to the point where indeed maybe the public would support it.

But there is another aspect to this, and you touched on it in your statement. Your estimate of payback to the Treasury in fiscal year 1986 would be approximately $110 million. But we did discuss this issue on April 10, during the uranium hearing, that the Consolidated Omnibus Budget Reconciliation Act of 1985, signed into law by the President on April 7, provides only the ceilings for repayment for the next three years.

The ceiling for fiscal year 1986 is $100 million, and $150 million for fiscal year 1987 and 1988. Besides, the Secretary must determine the amount of repayment, taking into consideration the reliability and competitiveness of the program.

Is it inconsistent with the law to continue to project $110 million in fiscal year 1986, and $235 million in fiscal year 1987?

Mr. VAUGHAN. Senator, and please understand I am not trying to avoid a direct answer to your question, we have asked our budget office and our legal office to do a thorough review of those items to make sure that we operate consistent with the law. A couple of people have read it differently and I am trying to make sure we comply with both the literal, as well as the intent of the law.

The CHAIRMAN. Let me ask another question which is technical in nature. If you intend to pay back $235 million to the Treasury, how can it be zero net appropriation?

Mr. VAUGHAN. Here, again, our budget office has, in conjunction with OMB, advised that what we are requesting is an amount of budget authority which, added to the amount of repayment, equals the forecast revenues and that that does represent a net zero accounting.

The CHAIRMAN. That is a constructive use of either accounting or tables or words and I am not sure which.

Mr. VAUGHAN. Certainly, as you know, I am in no way trying to be evasive to your question.

The CHAIRMAN. I understand that, but it seems to me that the policy is, whether you are or not.

Let me pursue that a little further in a different vein. DOE has been trying to capture uncommitted markets. You have signed contracts with utilities into the 1990's with much reduced price for their enrichment requirements, and those prices are in the range of $135 per SWU in 1985, to $85 per SWU in 1995.

You have had a favorable response to that strategy. How can you be sure that you can meet that price if the administration also, at the same time, plans to repay $3.5 billion from the program to the Treasury? Are we going to get into another mess in accounting?

Mr. VAUGHAN. Mr. Chairman, let me respond to that question in two parts. Literally, with respect to the contracts, the amount of the base price, which is the first 70 percent of the requirements of a utility, those contracts for a given price are made on a year-by-year basis, with the 1987 price forecasted and announced at $119 per SWU. We also had an incentive price offering for the top 30 percent, which does go at prices as low as $85 plus escalation for that top 30 percent through 1995.

We have projected the cost of production, the amount to be produced, as well as the amount to be repaid to the Treasury in our budget forecast and believe we can meet those commitments without raising the prices.

Among the premises of our discussions with OMB, the first premise is that we must remain competitive and reliable in the uranium enrichment enterprise.

The CHAIRMAN. And if the payment of $3.4 billion, repayment of $3.4 billion—whatever—whether it is payment or repayment is in conflict with that goal, which gives?

Mr. VAUGHAN. Presumably, the precise number would have to be reexamined and certainly the annual levels of the payment are what are subject to examination on a basis with 2-year projections consistent with the budget cycle.

The CHAIRMAN. It seems to me, and it must be obvious by now, and that is my conclusion at this point, that the two stated administration goals are in direct conflict and irreconcilable. If I am wrong, I need to be persuaded.

Which then leads to the question of, if they are so, obviously, irreconcilable, which one is the administration really pushing? Perhaps you are not the right person to ask that question because I suspect the alternative is embedded in OMB philosophy.

Mr. VAUGHAN. The only thing I would add is that the Department's position, as articulated by the Secretary as well as myself, and Mr. Longenecker, who is here with me, a number of times, is that we are committed to continue to be a competitive and reliable supplier, both for our commercial customers, as well as for our——

The CHAIRMAN. I am sure that is true, but indeed there is a conflicting policy that makes that impossible, then you will have been frustrated in your stated intent and they will have won the day without ever having joined the battle.

Senator Hecht.

Senator HECHT. As you know, we have a short timeframe. I would prefer to give my questions in writing and go on and hear the next witnesses.

The CHAIRMAN. Thank you, very much, Senator. I have a number of other questions also which will be submitted for the record. Other members of the committee may also have until the close of business tomorrow to submit questions in writing for response.

Thank you, very much.

Mr. VAUGHAN. Thank you, Mr. Chairman. It is always a pleasure to appear before this committee, and let me again emphasize how much we appreciate your constructive interest in these programs.

The CHAIRMAN. Thank you, very much.

We have two other groups to hear from; one is the Nuclear Regulatory Commission, Mr. Victor Stello, who we will hear from next, and then the military applications. We do propose to complete the hearing.

Mr. Stello, your prepared statement will be placed in the record in full. At this point, I would invite you to summarize in as brief a manner as you can so we can proceed to questions.

STATEMENT OF VICTOR STELLO, EXECUTIVE DIRECTOR FOR OPERATIONS, NUCLEAR REGULATORY COMMISSION, ACCOMPANIED BY ROBERT B. MINOGUE, DIRECTOR, OFFICE OF NUCLEAR REGULATORY RESEARCH, AND DR. CHARLES KELBER, ASSOCIATE DIRECTOR FOR SCIENTIFIC PROGRAMS, OFFICE OF NUCLEAR REGULATORY RESEARCH

Mr. STELLO. Thank you, very much, Mr. Chairman. I have asked with your permission to have Mr. Minogue, who is Director of our Office of Research, join me at the table, as well as Mr. Kelber, who is the Associate Director for Scientific Programs.

I am certainly pleased to have an opportunity to appear before you today, to summarize NRC's views on the Department of Energy's program for research and development of civilian nuclear power and the disposal of the waste from such plants. The NRC and DOE have enjoyed a productive and harmonious relationship; we want it to continue and offer some comments on ways we think it could be strengthened.

Before providing some specific comments, Mr. Chairman, I would like to offer some general remarks on the importance of nuclear safety research, an area I feel rather strongly about.

Nuclear power is a product of one of the most comprehensive scientific research programs ever undertaken in the history of technology. The excellent safety record we have achieved with the peaceful application of nuclear technology is directly coupled to our Nation's nuclear research program.

A healthy and vital national research program is needed. Commercial application of nuclear power is a maturing industry. The several generations of plants which have evolved have provided considerable confidence that this technology can and is being applied safely.

New designs would, however, need the benefit of the insights of research and development in order to demonstrate the reliability

and safety of new concepts. Without the results of such efforts, regulatory acceptability of new concepts would be difficult if not impossible.

Both DOE and NRC have major roles in performing safety research. Both parties have an interest in maintaining U.S. test facilities and technical capabilities. NRC's major concern is that the technical infrastructure that supports further progress in the safe production of nuclear power not be further eroded.

For the future, we see five major areas of safety concern that require technical support. One, the aging and degradation in service; two, the system response to complex operational and thermohydraulic transients; three, severe accident issues; four, reactor operation and risk assessment; and five, seismic margin.

To these power reactor concerns I would add a sixth; waste disposal.

The NRC maintains a research program in each of these areas that focuses on our regulatory needs. It is much narrower than DOE's research program. Industrial and utility groups do their part, but the sharply reduced Federal budgets of the last few years are eroding our technical lead in nuclear power over Europe and Japan.

An important role for DOE has been the ownership and operation of major test facilities. Although these facilities have high base costs, the breadth of DOE's mission has permitted this cost to be spread among many interested parties.

The LOFT facility at your State, Idaho, was operated for 3 years by an international consortium under the auspices of OECD. The NRC was a major partner in this consortium. This program was well executed by DOE's contractor, but with the shutdown and scheduled decommissioning of LOFT and the power burst facility, we will have lost the capability for in-pile testing in the United States.

DOE's research at TMI-2 is an important program. This project, with substantial foreign as well as U.S. interests, has sponsored the retrieval of valuable information that the NRC has considered in guiding its severe accident work. Additional information is anticipated, particularly in support of decommissioning studies.

The NRC believes that continuing and strengthening the ability of DOE to carry out such broad scope programs is in the National interest. They provide an opportunity to seek out answers to complex operational problems in advance, rather than to try to answer them in real time at a nuclear powerplant. The NRC also believes that cooperative research generally improves the quality of the work and the acceptance of its results.

DOE's work is also unique in that DOE can be a bridge to commercialization of new technologies. Areas where efforts could be particularly useful are: Developing new, more reliable, and accurate safety systems; confirming the reliability of safety systems; and increasing the availability of safety systems.

In 1982, the NRC took the position that DOE has a very high potential for success in developing improved safety technology for U.S. powerplants. We cooperated fully with DOE in the development of its comprehensive management plan to implement Public

Law 96-567, Nuclear Safety Research, Development and Demonstration Act of 1980.

We continue to believe this plan is reasonable and, if implemented, should result in a program that will yield important safety information. With DOE taking the lead in starting up the technology and demonstrating its practicality, we believe there will be a very good chance of industry putting the technology to use.

A detailed examination of the DOE budget request for fiscal year 1987 shows only $3 million is devoted to increasing the reliability of currently operating plants. NRC would endorse expanding this program to include the full scope of issues identified in the Energy Research Advisory Board Report, DOE/SROO 24.

If I might digress for a moment, I was impressed when I looked at some numbers in terms of the availability and capacity factor of plants in the United States, where our average capacity factors are in the fifties, if you look to Japan, in the seventies, and West Germany, in the eighties—think about that for a moment with 100 operating plants, improving reliability 15 percentage points. You are talking about the equivalent of 15 1,000-megawatt electric plants, which would save the American people somewhere between $10 and $20 million per day.

The CHAIRMAN. I want you to repeat that statement, if you will.

Mr. STELLO. The difference between average capacity factors in the United States, versus foreign countries; if you look to Japan, where those numbers are averaged somewhere in the seventies; and in West Germany where they are in the eighties; would suggest that the technology clearly is available—to increase the average capacity factors, or availability of plants in this country 15 percentage points. Doing that would have the equivalent, with 100 operating plants, of 15 1,000-megawatt electric plants.

The CHAIRMAN. Is that without any additional investment?

Mr. STELLO. I make that comment in the context of looking at further ways for which we can improve the reliability and availability of our plants through additional programs that DOE could sponsor and the industry itself, of course, because their interests ought to be as real as anyone else's. But the point being that this is an important area and having only $3 million devoted in the budget to increasing the reliability doesn't seem necessarily like the right amount in light of the potential gains to benefit the American people with the increased operation of these plants, and hence, its reduced cost.

We are prepared to cooperate fully with DOE to review the designs of advanced plants consistent with available resources in order to set the stage for a more formal licensing submittal for the selected design.

I understand DOE is cooperating with industry on an advanced light-water reactor program and that part of that program will involve an effort by industry to subject plants to the design certification process anticipated in the Commission's standardization policy. This I would like to cite as a very encouraging approach, as a particular effort needed in our country to reform the way in which we go about licensing plants throughout proposed certification process.

I would now like to make a few general remarks on the important topic of waste management. DOE carries out an extensive and

broad program of research on the disposal of high-level waste, including liaison with other countries.

NRC's research and technical assistance program probes and verifies the quality and completeness of DOE's technical development activities and provides the technical base for NRC to review DOE's license application.

For low-level waste, DOE has the role of furthering low-level waste disposal technology. Yearly, DOE sponsors a meeting, attended by many interested parties, to update and distribute the latest technological findings in low-level waste disposal technology.

NRC's research involves establishing a sound technical basis for low-level waste regulation and advice to States on all aspects of low-level waste disposal.

In conclusion, I want to emphasize that the NRC believes DOE has a major research role to play in improving the safety of currently operating plants, as well as developing advanced designs.

The NRC is concerned that our capability to deal with future problems of nuclear powerplants will be greatly impaired by a failure to deal now with the erosion of our technical support.

To illustrate this point, our research budget, in terms of constant dollars, will be lower in fiscal year 1987 than it was when the agency was formed in 1975. Between 1981 and 1987, the Nuclear Regulatory Research Program will have been reduced by more than $110 million, about 53 percent.

Joint programs with other parties and improved operating economies cannot make up for these reductions over the years. The reductions in the fiscal year 1987 research budget will mean an end to some programs and significant delays or deferral of others.

Without support from others, the technical infrastructure must suffer. My judgment is that an expanded DOE program aimed at improving the safety of currently operating plants, one that includes broad partnerships for maintaining key test facility capability, will play a vital role in maintaining U.S. technical leadership in nuclear powerplant and waste disposal technology.

Mr. Chairman, that concludes my prepared remarks.

The CHAIRMAN. Thank you very much.

Mr. STELLO. We are prepared to reply to your questions.

[The prepared statement of Mr. Stello follows:]

STATEMENT
BY THE

U.S. NUCLEAR REGULATORY COMMISSION

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

PRESENTED BY:

VICTOR STELLO, JR.
EXECUTIVE DIRECTOR FOR OPERATIONS

SUBMITTED: APRIL 29, 1986

I AM PLEASED TO APPEAR BEFORE YOU TO SUMMARIZE NRC VIEWS ON THE DEPARTMENT OF ENERGY'S PROGRAM OF RESEARCH AND DEVELOPMENT OF CIVILIAN NUCLEAR POWER AND THE DISPOSAL OF THE WASTE FROM SUCH PLANTS. THE NRC AND DOE HAVE ENJOYED A PRODUCTIVE AND HARMONIOUS RELATIONSHIP; WE WANT IT TO CONTINUE AND OFFER SOME COMMENTS ON WAYS WE THINK IT CAN BE STRENGTHENED.

BEFORE PROVIDING SPECIFIC COMMENTS, I WOULD LIKE TO OFFER SOME GENERAL REMARKS ON THE IMPORTANCE OF NUCLEAR SAFETY RESEARCH. NUCLEAR POWER IS A PRODUCT OF ONE OF THE MOST COMPREHENSIVE SCIENTIFIC RESEARCH PROGRAMS EVER UNDERTAKEN IN THE HISTORY OF TECHNOLOGY. THE EXCELLENT SAFETY RECORD WE HAVE ACHIEVED WITH THE PEACEFUL APPLICATION OF NUCLEAR TECHNOLOGY IS DIRECTLY COUPLED TO OUR NATION'S NUCLEAR RESEARCH PROGRAM. A HEALTHY AND VITAL NATIONAL RESEARCH PROGRAM IS NEEDED. COMMERCIAL APPLICATION OF NUCLEAR POWER IS A MATURING INDUSTRY. THE SEVERAL GENERATIONS OF PLANTS WHICH HAVE EVOLVED HAVE PROVIDED CONSIDERABLE CONFIDENCE THAT THIS TECHNOLOGY CAN BE AND IS BEING APPLIED SAFELY. NEW DESIGNS WILL, HOWEVER, NEED THE BENEFIT OF THE INSIGHTS OF RESEARCH AND DEVELOPMENT IN ORDER TO DEMONSTRATE THE RELIABILITY AND SAFETY OF NEW CONCEPTS. WITHOUT THE RESULTS OF SUCH EFFORTS REGULATORY ACCEPTABILITY OF NEW CONCEPTS WOULD BE DIFFICULT IF NOT IMPOSSIBLE.

BOTH DOE AND NRC HAVE MAJOR ROLES IN PERFORMING SAFETY RESEARCH. BOTH PARTIES HAVE AN INTEREST IN MAINTAINING U.S. TEST FACILITIES AND TECHNICAL CAPABILITIES. NRC'S MAJOR CONCERN IS THAT THE

TECHNICAL INFRASTRUCTURE THAT SUPPORTS PROGRESS IN THE SAFE PRODUCTION OF NUCLEAR POWER NOT BE FURTHER ERODED.

FOR THE FUTURE WE SEE FIVE MAJOR AREAS OF SAFETY CONCERN THAT REQUIRE TECHNICAL SUPPORT: (1) AGING AND DEGRADATION IN SERVICE; (2) SYSTEM RESPONSE TO COMPLEX OPERATIONAL AND THERMO-HYDRAULIC TRANSIENTS; (3) SEVERE ACCIDENT ISSUES; (4) REACTOR OPERATION AND RISK ASSESSMENT; AND (5) SEISMIC MARGIN. TO THESE POWER REACTOR CONCERNS I WOULD ADD A SIXTH: WASTE DISPOSAL. THE NRC MAINTAINS A RESEARCH PROGRAM IN EACH OF THESE AREAS THAT FOCUSES ON OUR REGULATORY NEEDS. IT IS MUCH NARROWER THAN DOE'S RESEARCH PROGRAM. INDUSTRIAL AND UTILITY GROUPS DO THEIR PART, BUT THE SHARPLY REDUCED FEDERAL BUDGETS OF THE LAST FEW YEARS ARE ERODING OUR TECHNICAL LEAD IN NUCLEAR POWER OVER EUROPE AND JAPAN.

AN IMPORTANT ROLE FOR DOE HAS BEEN THE OWNERSHIP AND OPERATION OF MAJOR TEST FACILITIES. ALTHOUGH THESE FACILITIES HAVE HIGH BASE COSTS, THE BREADTH OF DOE'S MISSION HAS PERMITTED THIS COST TO BE SPREAD AMONG MANY INTERESTED PARTIES.

THE LOFT FACILITY AT IDAHO NATIONAL ENGINEERING LABORATORY WAS OPERATED FOR THREE YEARS BY AN INTERNATIONAL CONSORTIUM UNDER THE AUSPICES OF OECD. THE NRC WAS A MAJOR PARTNER IN THIS CONSORTIUM. THIS PROGRAM WAS WELL EXECUTED BY DOE'S CONTRACTOR, INEL, BUT WITH THE SHUTDOWN AND SCHEDULED DECOMMISSIONING OF LOFT AND THE POWER BURST FACILITY WE WILL HAVE LOST THE CAPABILITY FOR IN-PILE TESTING IN THE U.S.

DOE'S RESEARCH AT TMI-2 IS AN IMPORTANT PROGRAM. THIS PROJECT, WITH SUBSTANTIAL FOREIGN AS WELL AS U.S. INTERESTS, HAS SPONSORED THE RETRIEVAL OF VALUABLE INFORMATION THAT THE NRC HAS CONSIDERED IN GUIDING ITS SEVERE ACCIDENT WORK. ADDITIONAL INFORMATION IS ANTICIPATED, PARTICULARLY IN SUPPORT OF DECOMMISSIONING STUDIES.

THE NRC BELIEVES THAT CONTINUING AND STRENGTHENING THE ABILITY OF DOE TO CARRY OUT SUCH BROAD SCOPE PROGRAMS IS IN THE NATIONAL INTEREST. THEY PROVIDE AN OPPORTUNITY TO SEEK OUT ANSWERS TO COMPLEX OPERATIONAL PROBLEMS IN ADVANCE RATHER THAN TO TRY TO ANSWER THEM IN REAL TIME AT A NUCLEAR POWER PLANT. THE NRC ALSO BELIEVES THAT COOPERATIVE RESEARCH GENERALLY IMPROVES THE QUALITY OF THE WORK AND THE ACCEPTANCE OF ITS RESULTS.

DOE'S WORK IS ALSO UNIQUE IN THAT DOE CAN BE A BRIDGE TO COMMERCIALIZATION OF NEW TECHNOLOGIES. AREAS WHERE EFFORTS COULD BE PARTICULARLY USEFUL ARE: (1) DEVELOPING NEW, MORE RELIABLE AND ACCURATE SAFETY SYSTEMS; (2) CONFIRMING THE RELIABILITY OF SAFETY SYSTEMS; AND (3) INCREASING THE AVAILABILITY OF SAFETY SYSTEMS. IN 1982, THE NRC TOOK THE POSITION THAT DOE HAS A VERY HIGH POTENTIAL FOR SUCCESS IN DEVELOPING IMPROVED SAFETY TECHNOLOGY FOR U.S. POWER PLANTS. WE COOPERATED FULLY WITH DOE IN THE DEVELOPMENT OF ITS COMPREHENSIVE MANAGEMENT PLAN TO IMPLEMENT PUBLIC LAW 96-567, "NUCLEAR SAFETY RESEARCH, DEVELOPMENT, AND DEMONSTRATION ACT OF 1980." WE CONTINUE TO BELIEVE THIS PLAN IS REASONABLE AND, IF IMPLEMENTED, SHOULD RESULT IN A PROGRAM THAT WILL YIELD IMPORTANT SAFETY INFORMATION. WITH DOE TAKING THE LEAD IN

STARTING UP THE TECHNOLOGY AND DEMONSTRATING ITS PRACTICALITY, WE BELIEVE THERE WILL BE A VERY GOOD CHANCE OF INDUSTRY PUTTING THE TECHNOLOGY TO USE.

A DETAILED EXAMINATION OF THE DOE BUDGET REQUEST FOR FY 1987 SHOWS ONLY $3 MILLION IS DEVOTED TO INCREASING THE RELIABILITY OF CURRENTLY OPERATING PLANTS. NRC WOULD ENDORSE EXPANDING THIS PROGRAM TO INCLUDE THE FULL SCOPE OF ISSUES IDENTIFIED IN THE ENERGY RESEARCH ADVISORY BOARD REPORT (DOE/SR00 24).

I UNDERSTAND DOE HAS INCLUDED IN ITS REQUEST, FUNDS TO ENCOURAGE THE INDUSTRY TO SUBJECT PLANTS TO THE DESIGN CERTIFICATION PROCESS ANTICIPATED IN THE COMMISSION'S STANDARDIZATION POLICY. THIS IS AN ENCOURAGING APPROACH.

I WOULD NOW LIKE TO MAKE A FEW GENERAL REMARKS ON THE IMPORTANT TOPIC OF WASTE MANAGEMENT. DOE CARRIES OUT AN EXTENSIVE AND BROAD PROGRAM OF RESEARCH ON THE DISPOSAL OF HIGH LEVEL WASTE, INCLUDING LIAISON WITH OTHER COUNTRIES. NRC'S RESEARCH AND TECHNICAL ASSISTANCE PROGRAM PROBES AND VERIFIES THE QUALITY AND COMPLETENESS OF DOE'S TECHNICAL DEVELOPMENT ACTIVITIES AND PROVIDES THE TECHNICAL BASE FOR NRC TO REVIEW DOE'S LICENSE APPLICATION.

FOR LOW LEVEL WASTE, DOE HAS THE ROLE OF FURTHERING LOW LEVEL WASTE DISPOSAL TECHNOLOGY. YEARLY, DOE SPONSORS A MEETING, ATTENDED BY MANY INTERESTED PARTIES, TO UPDATE AND DISTRIBUTE THE LATEST TECHNOLOGICAL FINDINGS IN LOW LEVEL WASTE DISPOSAL TECHNOLOGY. NRC'S RESEARCH INVOLVES ESTABLISHING A SOUND TECHNICAL BASIS FOR LLW REGULATION AND ADVICE TO STATES ON ALL ASPECTS OF LLW DISPOSAL.

IN CONCLUSION, I WANT TO EMPHASIZE THAT THE NRC BELIEVES DOE HAS A MAJOR RESEARCH ROLE TO PLAY IN IMPROVING THE SAFETY OF CURRENTLY OPERATING PLANTS AS WELL AS DEVELOPING ADVANCED DESIGNS. THE NRC IS CONCERNED THAT OUR CAPABILITY TO DEAL WITH FUTURE PROBLEMS OF NUCLEAR POWER PLANTS WILL BE GREATLY IMPAIRED BY A FAILURE TO DEAL NOW WITH THE EROSION OF OUR TECHNICAL SUPPORT. TO ILLUSTRATE THIS POINT, OUR RESEARCH BUDGET, IN TERMS OF CONSTANT DOLLARS, WILL BE LOWER IN FY 1987 THAN IT WAS WHEN THE AGENCY WAS FORMED IN 1975. BETWEEN 1981 AND 1987, THE NUCLEAR REGULATORY RESEARCH PROGRAM WILL HAVE BEEN REDUCED BY MORE THAN $110 MILLION, ABOUT 53 PERCENT. JOINT PROGRAMS WITH OTHER PARTIES AND IMPROVED OPERATING ECONOMIES CANNOT MAKE UP FOR THESE REDUCTIONS OVER THE YEARS. THE REDUCTIONS IN THE FY 1987 RESEARCH BUDGET WILL MEAN AN END TO SOME PROGRAMS AND SIGNIFICANT DELAYS IN, OR DEFERRAL, OF OTHERS. WITHOUT SUPPORT FROM OTHERS, THE TECHNICAL INFRASTRUCTURE MUST SUFFER. MY JUDGMENT IS THAT AN EXPANDED DOE PROGRAM AIMED AT IMPROVING THE SAFETY OF CURRENTLY OPERATING PLANTS, ONE THAT INCLUDES BROAD PARTNERSHIPS FOR MAINTAINING KEY TEST FACILITY CAPABILITY, WILL PLAY A VITAL PART IN MAINTAINING U.S. TECHNICAL LEADERSHIP IN NUCLEAR POWER PLANT AND WASTE DISPOSAL TECHNOLOGY.

The CHAIRMAN. Just very briefly, I guess I can characterize my summary of what has happened; NRC's budget has been severely constrained, progressively constrained over the years. That is not your desire, it is not my desire. It is the collective judgment of all the forces that bear on the total U.S. budget.

That has led first, a shift from NRC to DOE of all generic research as more and more of your research activities have been shifted to the licensing process, and the questions raised in licensing and not anticipating future problems.

Then, as you got more constrained, you have progressively shifted more of the safety research away from your own shop to DOE.

Mr. STELLO. That is fair, that they are carrying a larger burden because we are clearly carrying less, and they have——

The CHAIRMAN. And that pattern persists, does it not?

Mr. STELLO. Well, except that DOE's budget is also declining and they are obviously doing less of that, as well.

The CHAIRMAN. That is right.

Mr. STELLO. The net result is that there is in fact less being done.

The CHAIRMAN. Both in generic research, with respect to future activities, and also with respect to the safety aspects of current activities.

Mr. STELLO. That is correct. And the impact of that will most likely find its way in us regulators taking a more conservative view in terms of regulation.

The CHAIRMAN. What I see happening is people who do not like nuclear anything, first and successively assault public opinion, then based upon their success there, assault budgets, and then having crippled your capacity to act, attack your regulatory program as insufficient, thereby completing the loop which was their objective in the first place.

I think we must clearly identify that. I think we have no chance of winning the budgetary battle until we clearly identify what their goal is—not your goal nor mine, but there are others who feel that way about it. They do not want any nuclear anything, whether it is peaceful power or nuclear medicine, which they can barely tolerate simply because it saves lives, but they would much prefer to save lives some other way—that is the most favorable. Nuclear power is next, but, gee, they would rather have acid rain or no power, than to have nuclear power.

They would not certainly not like the fellows in blue suits behind you to have any at all. If they can cut out all of your budgets and all of your safety and all of your oversight, they may well have public support based upon your conservative approach because you can't be sure anymore.

Neat strategy, and apparently bearing some fruit.

The declining budgets have, as you have indicated in your testimony, closed a number of facilities. You have no in-pile facility remaining. What will you do if you have new safety questions that require prompt and thorough resolution? Where are you going to turn for answers?

Mr. STELLO. I would offer a hypothetical example. If someone wants to come up with different concepts in fuel design and we don't have the capability to do the kind of testing we need, we

may—at least conceptually—from a regulatory point of view find that design unacceptable.

The CHAIRMAN. Well, let us assume it is not a new design, but a new problem that surfaces with respect to an existing design.

Mr. STELLO. Then we may have to——

The CHAIRMAN. You cannot go to the library.

Mr. STELLO. No. We may have to take very conservative regulatory actions.

The CHAIRMAN. Stop using it?

Mr. STELLO. Well, let me give you some examples, as we look at the source term work that we have done, I think we have made advances in it but we are clearly in the areas of applying that technology going to have to make some fairly conservative assumptions because we don't have the full information. That directly relates to information that had we continued to have facilities such as PBF, we would have had better understanding of the parameters involved and a more complete assessment and, hence, been able to make a more reasonable adjustment in the consequences, based on that technical understanding which we will not have.

The CHAIRMAN. What experimental facilities are available in the United States today for the Office of Research to use in the event of incidents and accidents at nuclear powerplants, specifically thermohydraulic and severe core damage accidents?

Mr. STELLO. If I might, I would ask Mr. Minogue to answer that question. I think he is more familiar.

Mr. MINOGUE. Let me answer first the question about thermohydraulic capabilities. There is a facility for the boiling water reactors that is in stand-by. It is at the General Electric plant in San Jose and has completed its program. It is soon scheduled to be put out of commission. There is a similar facility for pressurized water reactors at Idaho in the Semiscale facility and another one at Alliance, OH, for the B&W configurations. All of these are basically at or near the end of their programs.

In the area of in-pile testing, as Mr. Stello said, basically there is no capability. There is a small reactor at Sandia that is used primarily for Defense Department programs at which some testing could be done, and we could also possibly get access to a reactor in Canada which has in-pile testing capabilities. But within the United States, in essence there will be no in-pile testing capability of any significant size or capability.

The CHAIRMAN. Has the Commission determined that a research capability should be maintained by the NRC for the future?

Mr. STELLO. Yes.

The CHAIRMAN. If so, and you have said yes; why, if nuclear energy is as safe as its advocates maintain?

Mr. STELLO. I think I have given in my testimony at least five examples of issues that are clearly still with us.

The CHAIRMAN. You have some unresolved safety issues.

Mr. STELLO. Yes, we do. I would point to aging, as we look at the plants that are getting older, there are phenomenon that are going to occur in the plants related to the age of the plant. Now that is important in terms of understanding whether or not and to what extent there are safety problems that might arise out of the result of the plants becoming older.

But there is also another aspect to this that concerns me and I fully expect that as these plants also get older, there might be a desire on the part of the utilities, and in fact some of them have expressed that desire, to want to extend the life of these facilities. In order to do that and go beyond the design life, there is going to be the need clearly for additional research work to support extending the life.

The CHAIRMAN. Mr. Stello, what you are saying to me is, I think, must be understood by the public. Let me rephrase it in as blunt a term as I know how to do, and I don't mean to overstate it.

In your statement you referred to operating gains that might be made, on the other of 15 percent, which with 100 reactors in operation, it would be the same as 15 1,000-megawatt reactors. Just by changes in the margins of safety.

You have suggested now that without research capability, you will become more conservative. That is moving in the other direction, is it not?

Mr. STELLO. It would be.

The CHAIRMAN. Rather than increasing the operability of the plants, you will, in order to be conservative, because the lack of capacity to determine—would impose more restrictions on operations.

Mr. STELLO. More stringent regulation.

The CHAIRMAN. And therefore, the availability of plants, the output of plants with respect to their design capability or their output plate capacity, would decline rather than increase unless you are able to verify safety parameters.

Mr. STELLO. Yes, I think I would prefer to say it in a slightly different way. And that is from a regulator's point of view; a plant that is operated safely, with high availability factors, high capacity factors, from our point of view, we are pleased because that is a very good operating plant for which equipment and people are behaving correctly. Unanticipated problems with the facility, where equipment and people do not perform well, obviously degrade the availability of the plant, as well as the lack of sufficient information which causes more stringent regulation, would also tend to reduce the capacity or availability.

The CHAIRMAN. And if it reduces the capacity, instead of being the same as 15 million megawatt, at 1,000-megawatt plants, a 15-percent reduction in availability would be the same as taking 15 out of operation.

Mr. STELLO. It would have the same effect.

The CHAIRMAN. And from the standpoint of ratepayers, multiplies their rates because they still have fixed investment to recover. Somehow, we have to get more adequate budgets.

You are under constraint; DOE is under constraint. Both of you have a tendency to say—leave it to the other—because of budget constraints, and there is a widening crack in which a lot of these safety considerations and operating considerations are falling.

Somehow we have to highlight that, and I would invite the Commission in its statements to point to that fact. I will also invite DOE to point to that fact.

I don't think we can any more say—you do it. I think somehow we have to adopt that notion that we have to do it, somewhere, somehow.

Thank you very much for your statement. We will be submitting questions for the record by the close of business tomorrow.

Mr. STELLO. Thank you, very much.

The CHAIRMAN. And now at last, we will hear from our final panel, Colonel Hess, Colonel Heilman, accompanied by Colonel McClain, and Mr. Stephen Hathaway.

STATEMENT OF COL. GEORGE HESS, USAF, DIRECTOR, SURVIVABILITY, LETHALITY & KEY TECHNOLOGIES, STRATEGIC DEFENSE INITIATIVE ORGANIZATION

The CHAIRMAN. Gentlemen, I am going to do something I am very reluctant to do, but I think in the interest of your time, as well as mine, I am going to place your prepared statements in the record, in full, and if there is no real reason or real need—there are very few at the press table, very few left in the room and only me up here—there is not really much reason to ask you to highlight the statement, unless you have a particular need to point to some specific things. If you do not need to do that, we can proceed directly to the questions.

Colonel HESS. That is fine, sir.

[The prepared statements of Colonel Hess and Colonel Heilman follow:]

STATEMENT ON

THE STRATEGIC DEFENSE INITIATIVE
SPACE POWER DEVELOPMENT POLICY

BY

COLONEL GEORGE HESS
DIRECTOR, SURVIVABILITY, LETHALITY & KEY TECHNOLOGIES (SLKT)

BEFORE THE

SUBCOMMITTEE ON ENERGY RESOURCES & DEVELOPMENT
COMMITTEE ON ENERGY & NATURAL RESOURCES
UNITED STATES SENATE

99Th CONGRESS, SECOND SESSION

APRIL 29, 1986

THANK YOU MR. CHAIRMAN FOR THE OPPORTUNITY TO TESTIFY BEFORE YOUR SUBCOMMITTEE TODAY. I AM COLONEL GEORGE HESS, DIRECTOR OF THE SURVIVABILITY, LETHALITY AND KEY TECHNOLOGIES (SLKT) OFFICE OF THE STRATEGIC DEFENSE INITIATIVE ORGANIZATION (SDIO). MY OFFICE IS RESPONSIBLE FOR SDI'S MAINLINE POWER DEVELOPMENT EFFORTS. THE FOCUS OF MY REMARKS TODAY WILL BE UPON THE ROLE OF THE DEPARTMENT OF ENERGY IN DEVELOPING POWER TECHNOLOGIES TO MEET THE PROJECTED NEEDS OF THE STRATEGIC DEFENSE INITIATIVE.

THE SUCCESS OF NEARLY ALL ELEMENTS OF SDI IS CRITICALLY DEPENDENT UPON MAJOR ADVANCES IN THE AREA OF POWER AND POWER CONDITIONING. ADVANCED SPACE BASED SYSTEMS FOR DEFENSE AGAINST BALLISTIC MISSILES WILL REQUIRE ELECTRICAL POWER OF TRULY UNPRECEDENTED LEVELS AND CHARACTERISTICS. THESE POWER AND VOLTAGE LEVELS EXCEED OUR PRESENT EXPERIENCE IN SPACE BASED SYSTEMS BY ORDERS OF MAGNITUDE. SOURCES CAPABLE OF GENERATING THE NECESSARY POWER WILL ALSO HAVE TO OPERATE WITH EXTREMELY HIGH LEVELS OF RELIABILITY WHILE CONCURRENTLY MEETING SEVERE CONSTRAINTS RELATIVE TO SIZE, WEIGHT, LIFE-CYCLE COST AND SURVIVABILITY. CLEARLY, SIGNIFICANT CHALLENGES ASSOCIATED WITH THE DEVELOPMENT OF POWER TECHNOLOGY FOR SPACE-BORNE SYSTEMS MUST BE MET IF THE POTENTIAL OF SDI IS TO BE REALIZED.

WHILE THE PRINCIPAL DRIVERS IN OUR POWER PROGRAM RESULT FROM THE POTENTIAL FOR SPACE APPLICATIONS OF THE TECHNOLOGY, EMERGING GROUND BASED WEAPONS CONCEPTS SUGGEST THAT WE SHOULD INVESTIGATE

POWER SOURCE/ENERGY STORAGE CANDIDATES FOR GROUND APPLICATIONS AS WELL. AN ANALYSIS OF THE VARIOUS OPTIONS AVAILABLE IS PRESENTLY BEING PERFORMED FOR US BY THE ARMY. THE CURRENT FOCUS OF THIS ANALYSIS IS ON IDENTIFYING THE TECHNOLOGY IMPLICATION OF ATTEMPTING TO MEET THE NEEDS, AND ON FORMULATING A RESPONSIVE R&D PROGRAM.

A CLOSER LOOK AT THE CURRENTLY PROJECTED MISSION REQUIREMENTS FOR SDI SPACE BASED SYSTEMS SHOWS THERE ARE THREE MAJOR CATEGORIES OF POWER REQUIREMENTS. THEY ARE: (1) HOUSEKEEPING POWER AT THE THE FEW HUNDRED KILOWATT LEVEL TO MAINTAIN SYSTEMS FUNCTIONS (i.e.., SURVEILLANCE, ACQUISITION, AND TRACKING) CONTINUOUSLY FOR YEARS; (2) ALERT MODE POWER AT THE MEGAWATT LEVEL FOR INTEGRATED TIMES OF UP TO PERHAPS A YEAR OVER THE TOTAL MULTI-YEAR MISSION CYCLE; AND, (3) BURST MODE REQUIRING HUNDREDS OF MEGAWATTS FOR TENS TO HUNDREDS OF SECONDS TO POWER THE WEAPONS SYSTEMS PRESENTLY ENVISIONED. NO PRESENTLY EXISTING SYSTEMS, SUBSYSTEMS, COMPONENTS OR DEVICES EVEN APPROACH THE ABILITY TO SATISFY THESE FORMIDABLE REQUIREMENTS.

IN RESPONSE TO THE CHALLENGES BEFORE US, A TECHNOLOGY PROGRAM AIMED AT SATISFYING THESE NEEDS HAS BEEN FORMULATED BY SDIO. THIS POWER PROGRAM WAS INITIATED AT A LOW LEVEL IN FY 1985 AND IS EFFECTIVELY A "NEW START" IN FY 1986. ITS GOAL IS TO ESTABLISH THE TECHNOLOGY BASE CRITICAL TO THE DEVELOPMENT OF SDI-REQUIRED POWER SOURCES AND PULSE POWER CONDITIONING SYSTEMS. THE PROGRAM WILL CONCENTRATE INITIALLY UPON ASSESSING THE VERY FEASIBILITY

OF ACHIEVING THE OVERALL CAPABILITIES REQUIRED, AND THEN UPON REALIZING THE SIGNIFICANT GAINS IN ENERGY DENSITY AND POWER DENSITY REQUIRED FOR SYSTEM REALISM. THE GOALS OF THE PROGRAM ARE TO BE MET THROUGH TECHNOLOGY ADVANCEMENTS AND PROOF-OF-PRINCIPAL TESTS ON CRITICAL POWER SOURCES AND CONDITIONING COMPONENTS AND DEVICES. FEASIBILITY WILL IN GENERAL BE EMBODIED, BY THE EARLY 1990'S, IN PROTOTYPICAL OPERATING HARDWARE AT THE APPROPRIATE SCALE. DUE TO THE MAGNITUDE AND SCOPE OF THE TECHNOLOGY CHALLENGES, WE HAVE CALLED UPON THE BROAD EXPERTISE RESIDENT IN A NUMBER OF AGENCIES WITHIN THE GOVERNMENT TO SUPPORT OUR EFFORTS. TO ENSURE RESPONSIVENESS TO EVOLVING REQUIREMENTS, THE PROGRAM IS CLOSELY COUPLED TO WEAPONS AND SYSTEMS EFFORTS UNDERWAY WITHIN SDIO. IN ADDITION, MAXIMUM INPUT FROM THE SCIENTIFIC COMMUNITY IS ASSURED THROUGH INTEGRATED AND JOINT EFFORTS WITH SDI'S INNOVATIVE SCIENCE AND TECHNOLOGY PROGRAM.

THE SDIO POWER PROGRAM IS CONCENTRATED IN FOUR MAJOR AREAS: (1) STUDIES, ANALYSES AND REQUIREMENTS; (2) BASELOAD TECHNOLOGY; (3) MULTIMEGAWATT TECHNOLOGY; AND, (4) PULSE POWER CONDITIONING TECHNOLOGY.

THE FOCUS OF THE ANALYSIS AND REQUIREMENTS ELEMENT IS ON EVALUATING THE FEASIBILITY OF CANDIDATE POWER TECHNOLOGIES IN THE CONTEXT OF THEIR INTERACTION WITH THE HOSTILE ENVIRONMENT OF SPACE, AND ON ASSESSING THE IMPACT ON THE ENVIRONMENT AND ON THE PLATFORM OF OPERATING POWER SYSTEMS OF THESE UNPRECEDENTED

CHARACTERISTICS. A KEY EFFORT IN THIS AREA IS THE INITIATION IN FY 1986 OF THE SDI POWER SYSTEMS ARCHITECTURE STUDIES. THESE STUDIES WILL FOCUS UPON THE SYSTEMS LEVEL INTEGRATION ISSUES AND ON EVALUATIONS OF THE POTENTIAL IMPACT OF INDIVIDUAL POWER SYSTEM EMPLOYMENT SCENARIOS UPON OVERALL WEAPONS PLATFORM OPERATION. FOR EXAMPLE, IN OPEN CYCLE SYSTEMS, WHERE EXHAUST FROM THE GENERATION OF POWER IS RELEASED INTO THE SPACE ENVIRONMENT, NO MEANS EXIST TO PREDICT THE MAGNITUDE OF THE DETRIMENTAL EFFECTS OF THE RESULTANT THRUSTS AND EFFLUENT CLOUDS UPON WEAPON POINTING, TRACKING AND BEAM PROPAGATION. ON THE OTHER HAND, WHILE CLOSED CYCLE SYSTEMS DO NOT SUFFER FROM EFFLUENT PROBLEMS, THEY ARE SIGNIFICANTLY MORE MASSIVE; SIZABLE INCREASES IN MASS AND VOLUME WILL OBVIOUSLY HAVE DELETERIOUS IMPACTS ON AFFORDABILITY AND SURVIVABILITY. THE EFFECT OF ON-BOARD ROTATING MACHINERY UPON PLATFORM STABILIZATION IS ANOTHER IMPORTANT CONSIDERATION. INVESTIGATIONS AND ASSESSMENTS OF ISSUES SUCH AS THESE WILL BE OF CENTRAL IMPORTANCE IN THE POWER ARCHITECTURE STUDIES. THE RESULTS OF THESE ASSESSMENTS WILL SET THE CONTEXT IN WHICH THE VARIOUS CANDIDATE POWER SYSTEM WILL BE CONFIGURED.

THE CORNERSTONE OF THE SDI BASELOAD POWER DEVELOPMENT IS THE SP-100 SPACE NUCLEAR REACTOR PROGRAM. ESTABLISHED IN 1983 AS A TRI-AGENCY EFFORT AMONG DOD, NASA AND DOE, THE SP-100 PROGRAM IS FOCUSED UPON DEVELOPING THE TECHNOLOGY BASE NEEDED TO PROVIDE SAFE, RELIABLE NUCLEAR-GENERATED ELECTRIC POWER IN THE RANGE OF A FEW 10S OF KILOWATTS UP TO APPROXIMATELY ONE MEGAWATT FOR A

VARIETY OF BOTH CIVIL AND MILITARY MISSIONS IN THE 1990'S AND BEYOND. THE PROGRAM HAS SUCCESSFULLY COMPLETED PHASE I, TECHNOLOGY ASSESSMENT, WITH THE OUT-OF-CORE THERMOELECTRIC CONCEPT SELECTED FOR FURTHER DEVELOPMENT AND GROUND DEMONSTRATION DURING PHASE II.

UNDER A NEW MEMORANDUM OF AGREEMENT (DATED 10/8/85) AMONG SDIO, NASA AND DOE, THE SP-100 PROGRAM HAS SUCCESSFULLY TRANSITIONED TO PHASE II - A FIVE YEAR EFFORT TO DESIGN, DEVELOP AND DEMONSTRATE IN GROUND TESTS THE OPERATION OF THE MAJOR SUBSYSTEMS OF A 300 KILOWATT ELECTRIC (KWE) NUCLEAR THERMOELECTRIC POWER SYSTEM. THE FOUR FUNCTIONAL ELEMENTS OF THE SP-100 PHASE II PROGRAM ARE: (1) SP-100 GROUND ENGINEERING SYSTEMS DEVELOPMENT; (2) SP-100 ADVANCED TECHNOLOGY; (3) CIVIL MISSIONS ANALYSIS AND REQUIREMENTS DEFINITION; AND, (4) MILITARY MISSIONS ANALYSIS AND DEFINITION. BEYOND PHASE II A REFERENCE MISSION FOR SP-100 HAS BEEN INITIALLY DEFINED AS A 1993 LAUNCH AND SPACE FLIGHT DEMONSTRATION OF A 300 KWE SP-100 SPACE REACTOR POWER SYSTEM DRIVING AN ELECTRIC PROPULSION UNIT. THIS FLIGHT DEMONSTRATION WOULD: (1) VERIFY ON-ORBIT OPERATION OF A SPACE QUALIFIED SP-100 SYSTEM; (2) DEMONSTRATE ORBIT TRANSFER CAPABILITY USING NUCLEAR ELECTRIC PROPULSION; AND, (3) DEMONSTRATE THE ABILITY TO MANUEVER AN ORBITING SPACECRAFT TO ENHANCE OPERATIONS AND SURVIVABILITY.

OVERALL PROGRAM MANAGEMENT AND COORDINATION OF PHASE II IS PROVIDED BY THE SDIO DIRECTOR THROUGH THE SDIO POWER MANAGER.

NASA IS SERVING AS THE PRINCIPAL AGENT FOR ADVANCED TECHNOLOGY AND CIVIL MISSIONS ANALYSIS AND REQUIREMENTS DEFINITION, AND IS CO-FUNDING THIS EFFORT, WHILE THE AIR FORCE IS RESPONSIBLE FOR MILITARY MISSIONS ANALYSIS AND REQUIREMENTS DEFINITION. THE DEPARTMENT OF ENERGY IS SERVING AS THE PRINCIPAL AGENT FOR THE GROUND ENGINEERING SYSTEMS AND IS CO-FUNDING THE DEVELOPMENT. THE HANFORD ENGINEERING DEVELOPMENT LABORATORY IS THE PREFERRED TEST SITE FOR THE REACTOR SUBSYSTEM TEST.

IN THE MULTIMEGAWATT AREA, TECHNOLOGY ASSESSMENT AND ADVANCEMENT EFFORTS ARE UNDERWAY ON AN ARRAY OF CONCEPTS WHICH COULD POTENTIALLY SUPPLY BURST MODE POWER WITH THE NEEDED CHARACTERISTICS. DUE TO THE POWER LEVELS AND TIME FRAMES INVOLVED, CANDIDATE CONCEPTS INCLUDE BOTH NUCLEAR AND NON-NUCLEAR SOURCES. SINCE RESEARCH AND DEVELOPMENT IN NEW NUCLEAR ENERGY SOURCES HAS LONG BEEN A TRADITIONAL AND IMPORTANT ROLE FOR THE DEPARTMENT OF ENERGY, AND SINCE THE TECHNICAL CAPABILITY AND MANAGEMENT EXPERTISE RESIDES WITHIN THAT AGENCY, THE DOE WAS CHOSEN TO PURSUE ALL EFFORTS RELATED TO NUCLEAR CONCEPTS AND ASSOCIATED TECHNOLOGIES. THE MULTIMEGAWATT TECHNOLOGY DEVELOPMENT PROGRAM REPRESENTS A MAJOR THRUST WITHIN THE SDIO POWER PROGRAM, AND DOE WILL BE CO-FUNDING THE NUCLEAR WORK.

BECAUSE OF THE DIVERSITY OF CANDIDATE TECHNOLOGIES IN THE NON-NUCLEAR ARENA, ALL THREE SERVICES ARE PURSUING DEVELOPMENTS CONSISTENT WITH THEIR BACKGROUND AND EXPERIENCE; THE AIR FORCE HAS

THE PREEMINENT ROLE IN THESE EFFORTS.

SDIO IS ASSISTED IN THE DEFINITION, SELECTION AND PRIORITIZATION OF TECHNOLOGY DEVELOPMENTS BY AN INDEPENDENT EVALUATION GROUP (IEG). THIS BODY, COMPOSED OF DOE, DOD AND NASA EXPERTS, PERFORMS SYSTEM ANALYSES AND TRADEOFF STUDIES, EVALUATES PROPOSALS AND ON-GOING EFFORTS WITHIN INDUSTRY, UNIVERSITIES, AND NATIONAL LABORATORIES. THE ROLE OF THE IEG IS CRITICAL IN CHOOSING AMONG COMPETING TECHNOLOGIES; IN ITS DELIBERATIONS THE IEG HAS AT ITS DISPOSAL THE TALENTS OF A MYRIAD OF DOD AND DOE CONSULTANTS. DAY-TO-DAY STUDIES AND ANALYSES ARE PERFORMED BY A GROUP OF SPACE POWER EXPERTS AT NASA LANGLEY RESEARCH CENTER AND BY A GROUP OF NUCLEAR AND POWER SYSTEM TECHNOLOGISTS AT SANDIA NATIONAL LABORATORY.

THE NUCLEAR MULTIMEGAWATT PROGRAM IS ORIENTED PRIMARILY TOWARD EVALUATION OF CONCEPTUAL APPROACHES, IDENTIFICATION OF CRITICAL TECHNOLOGY PATHS OR POTENTIAL SHOWSTOPPERS, AND CONDUCT OF THE GENERIC TECHNOLOGY ADVANCEMENTS NEEDED TO ESTABLISH CONCEPT FEASIBILITY.

NON-NUCLEAR TECHNOLOGIES BEING PURSUED INCLUDE ROTATING MACHINERY (TURBINES, GENERATORS, FLYWHEELS), ELECTROMECHANICAL SOURCES (BATTERIES, FUEL CELLS), AND MAGNETOHYDRODYNAMIC CONCEPTS. ALTHOUGH THE VAST MAJORITY OF THESE NON-NUCLEAR EFFORTS ARE CONTRACTED TO INDUSTRY, SEVERAL IMPORTANT DEVELOPMENTS ARE BEING

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CONDUCTED WITHIN THE NATIONAL LABORATORIES. INCLUDED ARE FLYWHEELS AT OAKRIDGE NATIONAL LABORATORY, FUEL CELL AT ARGONNE NATIONAL LABORATORY, AND PULSE ALTERNATORS THROUGH SANDIA NATIONAL LABORATORY. BROAD-BASED ASSESSMENT AND ADVANCEMENT EFFORTS WILL BE CONDUCTED THROUGH FY 88/89, AT WHICH TIME A DOWNSELECTION WILL RESULT IN A FOCUSING OF EFFORTS ON A SMALLER NUMBER OF LEADING CONTENDERS. THE FEASIBILITY OF THESE CONCEPTS WILL THEN BE MANIFESTED IN THE FABRICATION AND TEST OF DEMONSTRATION POWER SOURCES AT A SCALE APPROPRIATE TO THE PARTICULAR TECHNOLOGIES.

PULSE POWER CONDITIONING CONSISTS OF THOSE DEVICES AND COMPONENTS NEEDED TO MATCH THE ELECTRICAL CHARACTERISTICS OF THE POWER SOURCE WITH THOSE REQUIRED BY THE WEAPON. THE SEVERITY OF THE NEEDS IN THIS AREA CAN BE APPRECIATED BY EXAMINING THE DISPARITY BETWEEN TODAY'S CAPABILITY AND ANTICIPATED SDI REQUIREMENTS; IN SOME INSTANCES PROJECTED REQUIREMENTS EXCEED CURRENT CAPABILITIES BY TWO TO THREE ORDERS OF MAGNITUDE, EVEN IN THE CONTEXT OF GROUND-BASED EXPERIMENTS. IN MANY AREAS, NO SPACE-QUALIFIED HARDWARE EXISTS AT ANY POWER LEVEL. OUR PULSE POWER TECHNOLOGY DEVELOPMENT EFFORTS ARE FOCUSED UPON ESTABLISHING THE TECHNICAL FEASIBILITY OF MEETING SDI NEEDS IN POWER CONDITIONING CONSISTENT WITH STRINGENT CONSTRAINTS OF SIZE, WEIGHT AND EFFICIENCY. TECHNOLOGY AREAS INCLUDE CAPACITIVE AND INDUCTIVE ENERGY STORAGE, CLOSING AND OPENING SWITCHES, TRANSFORMERS, RADIO FREQUENCY SOURCES, DC-DC CONVERTERS, ULTRA-HIGH VOLTAGE TECHNIQUES AND COMPONENTS, ETC. A GREAT MANY OF THESE ACTIVITIES ARE BEING CONDUCTED WITHIN OR AT THE DIRECTION OF THE NATIONAL LABORATORIES.

FOR EXAMPLE, LOS ALAMOS NATIONAL LABORATORY IS LEADING AND COORDINATING OUR EFFORT TO DEVELOP HIGH LEVEL RADIO FREQUENCY POWER SOURCES AND EXTREMELY HIGH POWER THYRATRONS; SANDIA NATIONAL LABORATORY IS GUIDING EFFORTS IN TRANSFORMERS, SPARK GAPS, MAGNETIC SWITCHES, AND HIGH VOLTAGE DIODES.

AS I SAID PREVIOUSLY, RESEARCH AND DEVELOPMENT TO ENABLE NEW NUCLEAR ENERGY SOURCES HAS LONG BEEN A TRADITIONAL AND IMPORTANT ROLE FOR THE DEPARTMENT OF ENERGY. DOE IS SUPPORTING THE STRATEGIC DEFENSE INITIATIVE POWER PROGRAM BOTH BY SERVING AS PRINCIPAL AGENT FOR OUR NUCLEAR POWER DEVELOPMENT PROGRAMS FOR ALL THREE POWER REGIMES (BASELOAD, ALERT AND BURST) AND BY PERFORMING OR DIRECTING CRITICAL PORTIONS OF THE NON-NUCLEAR PRIME POWER AND OF THE PULSE POWER DEVELOPMENT EFFORTS. THE ROLE OF DOE IN THIS WORK FAR SURPASSES THAT OF BEING MERELY SDIO'S AGENT; CONSISTENT WITH ITS ROLE IN NUCLEAR TECHNOLOGY, DOE IS ACTIVELY CO-FUNDING RESEARCH INTO THE NUCLEAR CONCEPTS NEEDED TO FULFILL SDIO NEEDS. IN OUR VIEW, THE DOE PARTICIPATION, MANAGEMENT, AND FISCAL SUPPORT ARE CRUCIAL TO THE SUCCESS OF THE SDIO POWER PROGRAM.

IN SUMMARY, THE DEVELOPMENT OF THE POWER CAPABILITIES NEEDED TO SATISFY SDI REQUIREMENTS WILL POSE EXCITING CHALLENGES TO OUR SCIENTIFIC AND ENGINEERING COMMUNITY WELL INTO THE NEXT DECADE. MEETING THESE CHALLENGES WILL CONTRIBUTE NOT ONLY TO THE OVERALL SUCCESS OF THE STRATEGIC DEFENSE INITIATIVE BUT ALSO TO

THE FUTURE OF OUR NATION'S CAPABILITIES IN SPACE WELL INTO THE NEXT CENTURY.

THIS COMPLETES MY FORMAL REMARKS. I WOULD LIKE TO THANK YOU ONCE AGAIN FOR THE OPPORTUNITY TO APPEAR BEFORE YOU. I WOULD BE HAPPY TO ANSWER ANY QUESTIONS THAT YOU MIGHT HAVE.

DEPARTMENT OF THE AIR FORCE

STATEMENT OF

COLONEL JAMES H. HEILMAN, USAF

DEPUTY DIRECTOR

HQ USAF DIRECTORATE OF SPACE

DEPUTY CHIEF OF STAFF PLANS AND OPERATIONS

BEFORE THE

COMMITTE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE

CONCERNING

AIR FORCE OPERATIONAL REQUIREMENTS

FOR

SPACE-BASED NUCLEAR POWER

APRIL 29, 1986

GOOD MORNING MISTER CHAIRMAN, MEMBERS OF THE SUBCOMMITTEE, AND DISTINGUISHED GUESTS. I AM JIM HEILMAN, THE DEPUTY DIRECTOR OF SPACE, HQ USAF DEPUTY CHIEF OF STAFF, PLANS AND OPERATIONS. IT IS MY PRIVILEGE TO REPRESENT THE AIR FORCE OPERATIONAL WORLD AND PRESENT OUR VIEWS ON THE IMPORTANCE OF SPACE-BASED NUCLEAR POWER. AS THE OFFICE RESPONSIBLE FOR TODAY'S OPERATIONAL SPACE CAPABILITY, I WILL FOCUS ON WHAT REQUIREMENTS NEED INCREASED POWER THAT NUCLEAR REACTORS CAN POTENTIALLY OFFER TO MAINTAIN AND ENHANCE THE MILITARY SPACE FORCE STRUCTURE IN THE FUTURE.

AS THE DOD MEMBER OF THE SP-100 SYSTEM SELECTION TEAM, I HAVE BEEN CLOSELY INVOLVED WITH THE SELECTION OF THE DIFFERENT TECHNOLOGIES, AND THEIR RELATIVE MERITS. AS YOU ARE AWARE, THERMOELECTRIC CONVERSION WAS SELECTED AS THE MOST COST AND OPERATIONALLY EFFECTIVE, NEAR-TERM SPACE-BASED NUCLEAR POWER CONVERSION CONCEPT. I WOULD LIKE TO DISCUSS THE RELATIVE OPERATIONAL FACTORS WHICH CONTRIBUTED TO THE SELECTION.

ONE OF THE MOST IMPORTANT ENABLING TECHNOLOGIES FOR OUR FUTURE ENDEAVORS IN SPACE, IS INCREASED POWER. NUCLEAR REACTOR TECHNOLOGY APPEARS TO OFFER A SOLUTION. TODAY, SOLAR/RTG SYSTEMS ARE USED PRIMARILY TO GENERATE .5 TO 1.5 KW'S OF POWER FOR OPERATIONAL SPACE-BASED SURVEILLANCE, WEATHER, AND COMMUNICATIONS SATELLITES. IT IS POSSIBLE TO SCALE UP SOLAR ENERGY ARRAYS UP TO 25 TO 50 KW'S, BUT THE STRUCTURE BECOMES VERY LARGE. THERE ARE PRACTICAL UPPER LIMITS TO RTG'S DRIVEN BY THERMAL DISTRIBUTION AND RADIOISOTOPE HALF LIFE. THEREFORE, SPACE-BASED REACTOR NUCLEAR POWER IS A PROMISING ENABLING SOURCE ABOVE APPROXIMATELY 10 TO 50 KW. IT IS SUCH A POWER SOURCE THAT WOULD

SUPPORT AIR FORCE REQUIREMENTS FOR WIDE AREA SURVEILLANCE, ATTACK WARNING/ATTACK ASSESSMENT, AND NEAR-REAL-TIME TARGETING PLUS SPACE SYSTEM ON-ORBIT SUPPORT AND CONTROL REQUIREMENTS. I WILL ADDRESS EACH OF THESE OPERATIONAL APPLICATIONS IN FURTHER DETAIL.

THE AIR FORCE, AS WELL AS THE NAVY, NEEDS WIDE AREA SURVEILLANCE. FOR THE AIR FORCE THIS REQUIREMENT ADDRESSES AIR DEFENSE AGAINST BOMBERS AND CRUISE MISSILES, WHILE THE NAVY IS FOCUSED ON FLEET DEFENSE FROM SIMILAR LONG RANGE AIR THREATS. A SPACE-BASED WIDE AREA SURVEILLANCE SYSTEM IS REQUIRED TO FULLY MEET THIS MISSION NEED FOR WORLDWIDE, TIMELY COVERAGE. ALTHOUGH UPGRADES TO OUR NORTH WARNING AND ESTABLISHMENT OF THE OVER-THE-HORIZON RADAR SYSTEM WILL IMPROVE AIR DEFENSE CAPABILITIES, A SPACE-BASED SYSTEM IS THE LONG-RANGE SOLUTION TO ACQUIRE A GLOBAL AIR DEFENSE CAPABILITY TO SUPPORT CONUS AND WORLD-WIDE FORCE COMMITMENTS. THIS SYSTEM IS CURRENTLY ENVISIONED AS A SPACE-BASED RADAR/INFRA-RED SYSTEM. THE SATELLITE WOULD COMBINE ADVANCED RADAR AND INFRA-RED SENSORS TO DETECT AIRCRAFT, CRUISE, AND BALLISTIC MISSILES. A CONTINUOUS DUTY-CYCLE RADAR DEMANDS HIGH POWER FOR TARGET RESOLUTION, ESTIMATES RUN BETWEEN 100-300 KW TO SUPPORT AN OPERATIONAL SYSTEM. THIS SYSTEM WOULD SUPPORT OUR OPERATIONAL REQUIREMENTS BY OFFERING ATTACK WARNING AND REAL-TIME TARGETING OF THREAT AIRCRAFT AND CRUISE MISSILES. THE HIGH LEVERAGE FROM SUCH A CAPABILITY IS THE ABILITY TO TRACK FROM OPERATIONAL THREAT ZONES, THUS MINIMIZING THE ATTACK ASSESSMENT IDENTIFICATIONS/FRIEND OR FOE AND FORCE SIZE ISSUES ASSOCIATED WITH EXISTING DEFENSE FENCE COVERAGE.

SPACE-BASED NUCLEAR POWER IS ALSO THE ENABLING TECHNOLOGY FOR EFFECTIVE MANAGEMENT OF SPACE SYSTEM ON-ORBIT SUPPORT AND CONTROL. THE ORBITAL TRANSFER VEHICLE (OTV) IS A CONCEPT OF AN ON-ORBIT UNMANNED SPACE SUPPORT SYSTEM THAT WOULD TRANSFER PAYLOADS FROM LOW TO HIGH ORBIT AND RETURN THEM FOR MAINTENANCE OR REPLENISHMENT. USING A NUCLEAR REACTOR TO POWER THE OTV'S PROPULSION SYSTEM IS VERY ATTRACTIVE. NUCLEAR POWER, CONVERTED TO ELECTRICAL PROPULSION, OFFERS HIGH PROMISE OF ENABLING US TO BUILD A REUSABLE TRANSFER VEHICLE THAT DOES NOT HAVE TO BE REFUELED IN SPACE AS CHEMICALLY PROPELLED SYSTEMS WOULD TODAY. THE PROJECTED POWER REQUIREMENTS RANGE BETWEEN 300 TO 1000 KW. A SIGNIFICANT LEVERAGE APPLICATION OF NUCLEAR REACTOR POWER IS ITS POSSIBLE DUAL USE AS PROPULSION AS WELL AS PAYLOAD POWER SOURCE. THIS WOULD SIGNIFICANTLY REDUCE THE COMPLEXITY OF MULTIPLE POWER SOURCES TO PERFORM DIFFERENT FUNCTIONS. THE PROPULSION CAPABILITY WOULD BE INVALUABLE TO ENHANCE MILITARY NEEDS. FOR SATELLITES, IT COULD ENABLE TIMELY MANEUVERS, THUS ENHANCING THE SURVIVABILITY OF THE SPACE SYSTEM. THIS LEADS ME INTO THE CONSIDERATION OF SUPPORT SUBSYSTEMS FOR A SPACE SYSTEM, AND THEIR NECESSARY POWER REQUIREMENTS.

ON-BOARD PROCESSING, ALLOWING DIRECT TO FIELD COMMANDER PAYLOAD DATA, PROMISES TO BECOME MORE IMPORTANT IN THE NEAR FUTURE. COMPUTING, ON-ORBIT MALFUNCTION ANALYSES, CORRECTIVE MAINTENANCE, AND ATTITUDE CONTROL, ARE EXAMPLES OF POWER DEMANDS ON TODAY'S BASELINE SYSTEM. ON-BOARD PROCESSING AND GREATER AUTONOMY OF SATELLITE HOUSEKEEPING FUNCTIONS DECREASES RELIANCE ON VULNERABLE GROUND STATIONS DURING STRESSING PERIODS AND ENABLES THE SATELLITE TO MAINTAIN STATUS QUO INDEPENDENT OF FULL TIME GROUND CONTROL. NUCLEAR POWER SOURCES

COULD SUPPORT ON-BOARD PAYLOAD PROCESSING AND SATELLITE HEALTH AND WELFARE AUTONOMY ALLOWING TIMELY RECONSTITUTION OF GROUND OPERATIONS, THUS ENHANCING SYSTEM ENDURABILITY AND MILITARY DETERRENCE.

HIGH POWER LEVELS BECOME INCREASINGLY IMPORTANT WHEN YOU CONSIDER THE POTENTIAL OF THE STRATEGIC DEFENSE INITIATIVE (SDI) RESEARCH. DIRECTED ENERGY, OR KINETIC ENERGY SYSTEMS, OR EVEN SPACE SURVEILLANCE, AND SPACE-BASED BATTLE MANAGEMENT SYSTEMS, WOULD REQUIRE POWER IN THE HUNDREDS OF KILOWATTS. SUCH APPLICATIONS HAVE DIRECT BEARING ON THE CURRENT AIR FORCE SPACE DEFENSE MISSION, ESPECIALLY SPACE-BASED SURVEILLANCE AND ASAT, EVEN IF SDI TECHNOLOGIES WERE NEVER OPERATIONALLY DEPLOYED FOR MISSILE DEFENSE.

THE SYSTEM SELECTION TEAM FOR THE SP-100 ADDRESSED THE FOLLOWING KEY CRITERIA. THE UNIQUE OPERATIONAL ADVANTAGES OF THE NEAR-TERM THERMOELECTRIC CONCEPT TO BE VERIFIED IN THE PENDING GROUND ENGINEERING SYSTEM (GES) PHASE INCLUDE:

- SAFETY: ALL CONCEPTS MET SAFETY REQUIREMENTS. NEEDS CONTINUING DEVELOPMENT ATTENTION.
- PERFORMANCE: MATCH PROJECTED OPERATIONAL REQUIREMENTS; NEEDS TO BE VERIFIED.
- RELIABILITY: STATIC CONVERSION MORE RELIABLE, PROVIDES BACKUP REACTOR FOR DYNAMIC CONVERSION; NEEDS TO BE VERIFIED.
- GROWTH: GROWTH POTENTIAL UP TO MW. SCALEABILITY NEEDS TO BE VERIFIED.
- SURVIVABILITY: CAN BE NUCLEAR AND LASER HARDENED; RELATIVELY SMALL SIZE.

- USER INTERFACE: USER FRIENDLY, CONFIGURED FOR REMOTE CONTROL ACTIVATION AND CONTROL.
- OPERATIONS: SYSTEM CAN BE DESIGNED TO MINIMIZE OPERATIONAL CONSTRAINTS; SIMPLE INTERFACE BETWEEN SATELLITE AND POWER SOURCE; 7-10 YEAR LIFETIME MATCHES PROJECTED DESIGN SATELLITE LIFE. NEEDS TO BE VERIFIED.

THE GROUND ENGINEERING SYSTEM PHASE IS ABSOLUTELY NECESSARY TO VERIFY THE HIGH TEMPERATURE DRIVEN TECHNOLOGIES FUNDAMENTAL TO A CONFIDENT MOVE INTO THE NEXT PHASE OF DEVELOPING AND DEPLOYING AN OPERATIONAL SPACE-BASED REACTOR SYSTEM. TESTING, EVALUATION, AND VERIFICATION ON THE GROUND WILL ENSURE A MORE RELIABLE OPERATIONAL SYSTEM IN SPACE.

IN CONCLUSION, THE SP-100 PROGRAM HAS HIGH PROMISE OF SUPPORTING HIGH LEVERAGE PAY OFF SYSTEMS TO SATISFY EVER INCREASING DEMANDS FOR WORLD-WIDE REAL-TIME SUPPORT TO MILITARY FORCES. ALTHOUGH A SPECIFIC AIR FORCE OPERATIONAL APPLICATION IS PREMATURE IN TERMS OF FY 88 POM BUDGETED PROGRAMS, POWER SHOULD NOT BE THE LIMITING NEED OF SYSTEM CAPABILITIES REQUIRED TO MATCH TODAY'S STRESSING THREAT AND TOMORROW'S EVER-EVOLVING DEMANDS. POWER SOURCES MUST BE PROVEN TO BE OPERATIONALLY COMPATIBLE TO MISSION NEEDS. THIS IS FUNDAMENTAL TO THE BUILDER AND OPERATOR. THE SP-100 THERMOELECTRIC PROGRAM, LEADING TO A 300 KW FLIGHT DEMONSTRATION DECISION IS NECESSARY TO PROVIDE A SOLID BASE OF UNDERSTANDING TO CONFIDENTLY SELECT POWER SOURCES FOR VITAL NEAR-TERM SPACE-BASED NATIONAL DEFENSE SYSTEMS.

The CHAIRMAN. I thank you very much for your consideration.

How crucial is power supply to the overall success of the SDI Program?

Colonel HESS. Sir, that is an excellent first question. It is the essence of my opening remarks, and so I will just give those. We are acutely aware of the importance of developing the technology base for advanced electrical power systems, particularly for those systems that must be packaged and operated in a space environment.

The availability of electrical power, conditioned electrical power must not be a constraint as our research scientists consider options for the various surveillance and weapons systems being examined for future ballistic defense capabilities. Accordingly, General Abrahamson has put high priority in advancing that technology base in both the baseload power area and the multimegawatt power area, as well as power conditioning.

The CHAIRMAN. To phrase the question a slightly different way, could the lack of a power supply system or the proper power range, size, or weight, be a program stopper for the SDI Program?

Colonel HESS. Yes, sir. It would clearly not permit us to pursue certain options.

The CHAIRMAN. Such as?

Colonel HESS. Electrically driven, directed energy weapons and certain types of surveillance platforms, and those surveillance platforms in particular are the eyes of the system that are critical to the successful functioning of any ballistic defense capability.

The CHAIRMAN. Let me approach the next question by telling you my concern, and then asking you the question. DOE's civilian reactor budget for fiscal year 1987 has been severely impacted by the military program and this committee would not want to see the civilian research program counted out by the various military demands that are being placed on DOE's budget. Rather, we would like to see the military programs supplementing the DOE's civilian research efforts.

With that as a background of my concerns, how much money are you prepared to contribute to the effort?

Colonel HESS. Sir, I believe in all areas of our program, the baseload power area of which the SP-100 is the main element, the multimegawatt power area and in the pulse power area, we are carrying our load. As a matter of fact, in the SP-100 area, our contribution in fiscal year 1987 is planned to be $50 million, which I believe is slightly above that which will be contributed by the Department of Energy.

In the multimegawatt area across the board, both nuclear and non-nuclear in 1987, we have requested $52 million, of which a great deal of it will go to the Department of Energy on a reimbursable basis. So, I believe, as Mr. Vaughan indicated, that indeed the programs that we are pursuing are a cost-shared basis and in some cases, particularly the SP-100, we are more than carrying our burden in the early portion of the program.

The CHAIRMAN. Let me take that as an example. I do not mean to be argumentative at all; I am seeking answers. I do not think the Department of Energy would be doing SP-100 at all if it were not for you. If that is true, why should there be 50-50 cost-sharing? Why should you not be paying it all?

Colonel HESS. Sir, the responsibility for, by law, for pursuit of the core elements of the technology, that is, the reactor technology is the responsibility of the Department of Energy.

To discharge those responsibilities, they feel in the prioritization of their programs, that they must be involved in terms of participation with funding so that they can have a meaningful say on the execution of the program.

The CHAIRMAN. You mean, if you provide all the bucks, they lose control?

Colonel HESS. Sir, there is a feeling on their part that they want to be able to participate both technically and with financial resources so that they have a great deal of control in the program.

We appreciate and absolutely need the support of the Department of Energy on the SDIO Program and understand that it is within our responsibility to prioritize their investment.

The CHAIRMAN. I understand that. I am not certain that I would understand why, if the law requires that they do the core development, that if it is done for you, why they should pay the bill. I can understand their desire to maintain control; that is what the law says. And I can understand that you do not want to circumvent either the law or to duplicate what they do by replicating everything that they do, but I am not really certain that I understand yet why that mandates that they put up 50 percent of the money, or close to it.

Colonel HESS. When they make a budget request to the Congress, they establish the priorities and we defer to their judgment on how they request their budgets.

The CHAIRMAN. Did they do that or did OMB do that?

Colonel HESS. No, sir. DOE was very instrumental in wanting to participate, continuing to participate in the SP-100 and the Multimegawatt Program.

The CHAIRMAN. Participate financially?

Colonel HESS. Yes, sir.

The CHAIRMAN. It was their request they put up their money?

Colonel HESS. Yes, sir. Not the OMB.

The CHAIRMAN. DOE has proposed in its fiscal year 1987 budget request the idea of assessing users fees on various outside agencies that use DOE facilities to conduct research. Would DOD be willing to pay its proportional share for use of those facilities?

Colonel HESS. Sir; I would have to have—as a general statement, I think it would be better for the Department to answer that one for the record, but as I am sure that in the current funding arrangement for SP-100 and the multimegawatt, part of the DOE request is for the use of those facilities and it is part of the cost-sharing arrangement. The 50-50 cost split, it would be hard in the final analysis to say what portion of the DOD money was being paid for facilities, or rental fees or things of that nature.

On a 100-percent reimbursible basis, I am sure that would be included—if that were to be the pay we would follow, I am sure that would be part of the cost of doing business.

But as you have pointed out, that is not the current arrangement.

The CHAIRMAN. It is not, and again, it is not because I do not want it to be done; I do want it to be done. I support your programs

and your activities, both in this committee and in the Appropriations Committee. But I am concerned about the diversion of DOE moneys away from the civilian programs, where there is such a budgetary stringency, just as I mentioned to the previous witnesses and I think you were present at the time that exchange took place.

I think we are dangerously underfunding some other activities that are also essential. I will not even say they are more or less essential than what you are doing, because I think they are both essential.

We will submit some further questions for the record, and other Members of the committee will have some also. They will have until close of business tomorrow to submit those questions.

We would appreciate your prompt response.

Colonel HESS. Yes, sir.

The CHAIRMAN. And I cannot conclude the hearing without thanking you for your patience and bearing with us this morning, and also the abbreviated nature of your appearance. It is certainly not because the members of this committee have less interest, it is just that at this hour they have conflicts.

We thank you very much for your attendance.

The meeting will stand in adjournment.

[Whereupon, at 1:05 p.m., the hearing was adjourned, subject to the call of the Chair.]

APPENDIX III

Responses to Additional Committee Questions

Department of Energy
Washington, DC 20585

June 10, 1986

Honorable Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On April 29, 1986, Ben C. Rusche, Director of the Office of Civilian Radioactive Waste Management, appeared before the Energy and Natural Resources Subcommittee on Energy Research and Development to discuss the FY 1987 budget authorization for civilian radioactive waste management.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Mike Gilmore or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

APRIL 29, 1986 HEARING

BEFORE THE

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

WITNESS: BEN C. RUSCHE

DIRECTOR, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

U.S. DEPARTMENT OF ENERGY

QUESTIONS FROM SENATOR MCCLURE
MRS

QUESTION 1: What is the status of the MRS proposal?

ANSWER: The proposal and supporting documentation were completed in early February 1986, and were ready to be transmitted to the Congress. On February 7, 1986, the State of Tennessee's Attorney General successfully obtained an injunction from the Federal District Court for the Middle District of Tennessee which enjoined the Department from submitting the MRS proposal to the Congress. The injunction has been appealed by the Department.

QUESTION 2: The December review copy of the DOE proposal claimed the MRS would provide several substantial benefits to the overall waste system. Please explain.

- How an MRS would help implement the overall system?
- How would it help utilities?
- How would it help the first repository?
- How would it help the operations of the system?
- How would it help the transportation system?

ANSWER:

- An MRS would help implement the overall waste system by allowing earlier implementation of the waste receipt and preparation functions which are distinctly separate from repository siting and geologic considerations (i.e., implementing the system in a two-step process and starting sooner with the first step).

- The waste system with an MRS would help the utilities by allowing the Federal waste system to receive significant quantities of spent fuel from the utilities on an earlier schedule, thus providing a firm planning basis. As currently planned, the waste system with an MRS could receive 3,000 metric tons of spent fuel per year in 1998, whereas the repository-only system would only emplace 400 metric tons per year during Phase I operation from 1998 thru 2001. This will also significantly reduce the extent to which utilities will need to add new, temporary at-reactor storage capacity.

- The MRS would help the first repository by performing many of the spent fuel pre-emplacement preparation activities, e.g., initial fuel receipt and inspection, consolidation and placement in canisters, etc., at a facility centrally located to reactor population instead of at the repository. The repository would then receive uniform canisters of pre-packaged wastes from the MRS by regularly-scheduled dedicated train shipments from the MRS. Because the MRS would be licensed and operated before the first repository, issues related to the waste receipt and handling would be addressed earlier and the technology demonstrated prior to repository licensing. This would allow the repository licensing to focus more narrowly on the important geologic issues.

- The operations of the waste management system would be enhanced with an MRS by adding flexibility to accommodate changes in the repository emplacement schedule without affecting waste-acceptance operations from the reactors. In addition, decoupling of the geologic emplacement functions from the waste preparation functions brought

about by the inclusion of an MRS would increase system efficiency, reliability, and availability by allowing separate control of the operational rates of these major system components.

- The MRS would bring greater management and control to the waste transportation system by significantly reducing the number of cross-country waste shipments. The MRS would also greatly reduce the number of waste shipment miles in the system. Since waste shipment miles would be much lower with an MRS in the system, the likelihood of truck or rail accidents with the waste casks present would similarly be reduced. The implementation of the MRS facility would also provide a greater planning certainty resulting from earlier consideration of transportation routes. Defining logistics, routing and transportation equipment earlier would also assist utility and State and local agencies in their planning efforts.

QUESTION 3: What is the licensing process for the MRS, and how does it differ from licensing a repository? Will licensing an MRS be any easier or faster than a repository?

ANSWER: Surface facilities, similar to an MRS, have been licensed numerous times. The salient points of the MRS licensing process are the following:

- o Conformance with the requirements of 10 CFR 72 "Licensing requirements for independent spent fuel storage facilities.";
- o Emphasis is on safe handling and storage of nuclear material;
- o Siting not tied to demonstrated long-term geologic isolation considerations;
- o Involves demonstrated practices and processes; and
- o Focus is relatively near term.

In comparing MRS licensing with the repository licensing process, the following distinctions can be noted:

- o Repository is licensed under 10 CFR 60;
- o Repository license must address considerations related to waste isolation:
  - Subsurface geotechnical considerations
  - Focus is long term
- o More complex issues for repository licensing.

- o Far less restrictive technical siting requirements for MRS versus the need for extensive at-depth exploration for a repository; and,

- o Decommissioning at the repository emphasizes postclosure activities with site restricted permanently versus less complex MRS decommissioning moving quickly with site available for other uses.

As to whether MRS licensing can be easier and faster:

- o Both repository and MRS licensing are estimated to take from 2 to 3 years; both schedules are dominated by procedural considerations. MRS license application would be expected to be submitted in late 1988. The repository license application would be submitted in 1991.

- o MRS licensing should be less complex, the health and safety issues are not as complex.

- o MRS licensing on an earlier schedule should provide a good licensing basis and operational demonstration of the materials receipt and handling systems which are common to both facilities.

QUESTION 4: Why is it of such importance that the Congress consider the MRS proposal now?

ANSWER: The Department believes prompt consideration of the proposal is important for two reasons.

First, the Congress in the Nuclear Waste Policy specifically indicated that: "the executive branch and the Congress should proceed as expeditiously as possible to consider fully a proposal for construction of one or more monitored retrievable storage facilities...".

Second, many of the waste system benefits of the MRS are directly related to early Congressional action. These include:

- Demonstrating measurable progress in the waste program by "getting on with the job", thus enhancing public and utility confidence that the nation is taking positive action towards final disposal;
- Beginning operation in 1996 and allowing the Federal system to accept up to 14,000 metric tons of spent fuel by 2003 when the repository is scheduled to be operating at full capacity.
- Earlier definition, development and operation of the transportation system.

- Gaining institutional experience that could be applicable to the first repository effort by working with State and local officials in a State with an approved site; and,
- Debate on need and timing for the second repository could be much more meaningful if the three first repository sites are into site characterization and a direction on MRS has been established. (On May 28, the President approved three sites for characterization and postponed indefinitely site-specific work for a second repository).

QUESTIONS FROM SENATOR PETE V. DOMENICI
MRS

QUESTION 1: Mr. Rusche, would you please explain to this Committee your actions leading up to announcing sites in Tennessee?

ANSWER: Because of the ongoing court case relative to the MRS siting process, the Department believes it would be inappropriate to respond to this question. The U.S. District Court for the Middle District of Tennessee by order issued February 7, 1986, permanently enjoined "the DOE from making any proposal to Congress or filing any documents with Congress which rely on siting studies developed prior to consultation and cooperation between the DOE and the State of Tennessee, pursuant to..." Section 117(b) of the Nuclear Waste Policy Act. The Department has appealed the court decision and order.

QUESTION 2: Mr. Rusche, would you please describe the efforts your program office is currently undertaking in regards to siting and design of the MRS?

ANSWER: The DOE siting effort was completed with printing of the final MRS proposal containing the site-specific information prescribed in the NWPA. Final site selection is not within the Department's authority.

The conceptual design efforts were also complete prior to the printing of the final proposal. Contract close out and completion of support documentation is continuing.

QUESTION 3: What actions have the Department taken subsequent to the court imposed injunction to work with the State in furthering and developing the relationship between DOE and the State of Tennessee?

ANSWER: The Department has responded to verbal requests for information and given briefings at the request of local groups. The Department believes that further development of the relationship between DOE and the State will be better accomplished after pending legal issues are resolved.

SECOND REPOSITORY

QUESTION 1: Would you explain to the Committee the amount in the DOE FY87 request specified for work on the second repository and how that money will be spent?

ANSWER: The budget request for FY 1987 reflects an increase of $43,200,000 over the FY 1986 appropriation. The increase will provide for: preparation for area phase field studies in the crystalline rock repository project; expanded cooperative efforts with the Atomic Energy of Canada Limited/Underground Research Laboratory and the Swedish/Stripa projects; grants to affected States and Indian tribes; and engineering activities related to waste package and repository design. Listed below is a distribution, by work breakdown structure, of the Second Repository FY 1987 Budget Request.

	Budget Authority (dollars in thousands)
Systems	5,900
Waste Package	1,100
Siting	45,700
Repository Development	3,800
Regulatory and Institutional	8,900
Exploratory Shaft	---
Test Facilities	7,500
Land Acquisition	800
Project Management	5,000
Total	78,700

In light of the Secretary's announcement on May 28, 1986 regarding the indefinite postponement of site-specific activities on the second repository, we are in the process of descoping second repository activities and are currently reviewing non-site specific activity funding levels for FY 1987. We expect to have a revised estimate for FY 1987 in the near future.

QUESTION 2: What dollar amount, in your opinion, could Congress authorize for your Department in order for work to continue in the second repository while reflecting on the probable need for the second repository?

ANSWER: By deferring the initiation of area phase field investigations until May 1988, an FY 1987 funding level of $61,700,000, would permit work to continue on the second repository program while affording an opportunity to reflect on its probable need. However, as announced by the Secretary on May 28, 1986, site-specific work on a second repository has been postponed indefinitely. In view of this, we are currently reviewing non-site-specific activities and expect to have a revised estimate for FY 1987 by mid-June.

QUESTIONS FROM THE MINORITY
SECOND REPOSITORY

QUESTION 1: How much is it going to cost to have a second repository? Assume the first repository were expanded in size to encompass all spent fuel produced through 2020. Then how much would be saved if we cancelled the second repository program?

ANSWER: The second repository cost component of the January 1986 Total System Life-Cycle Cost (TSLCC) analysis ranges from $5.6 billion to $9.5 billion depending on the geological media finally selected. If the first repository was expanded in size to dispose of all spent fuel produced through 2020, the TSLCC costs for such a system would range from $18.5 billion to $29.0 billion depending on the geological media finally selected. Corresponding costs for a two-repository system based on the January 1986 analysis range from $23.6 billion to $32.3 billion depending on the geological media pair finally selected. Comparisons of specific cost savings (or additional costs) can only be made by specifically selecting the geology of the single large repository system and the geologies of the two-repository system. At this early stage of the program there is considerable uncertainty in the program cost estimates. Therefore, cost comparisons between a single-repository and a two-repository system must be considered preliminary. Within the multiple scenarios, current cost estimates indicate a savings

for a single-repository system as compared to a two-repository system, in most cases. However, there are scenarios that result in a cost increase for a single-repository system.

QUESTION 2: How much is being spent on the Second Repository in FY 1986? How much will be spent in FY 1987, 1988 and 1989?

ANSWER: It is estimated that a total of $37.2 million will be obligated for second repository activities in FY 1986. As presented in the FY 1987 Budget Request, estimates for FY 1987, 1988 and 1989 are $78.7 million, $74.2 million and $71.5 million, respectively. However, as announced by the Secretary on May 28, 1986, site-specific work on a second repository has been postponed indefinitely. In view of this, we are currently reviewing non-site-specific activities for FY 1987, 1988 and 1989, and expect to have revised estimates by mid-June.

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QUESTION 3: To what extent can extended burnup reduce the need for additional repository capacity over the next 25-30 years?

ANSWER: Extended burnup can reduce the tonnage of spent fuel discharged per year, roughly in inverse proportion to the percent of increase in burnup levels achieved. However, the reduction in the amount of metric tons of uranium of spent fuel achieved through extended burnup does not provide for corresponding reduction in the physical size of the repository. This is because of the higher heat loads generated by the higher burnup fuel. Higher burnup reduces tonnage but total heat per ton is actually higher. It should also be noted that increases in plant capacity factors (MW-generated over MW-installed) at nuclear power plants would increase the average annual generation of spent fuel which could offset reductions from extended burnup.

QUESTION 4: What technical obstacles do you know about or do you foresee in expanding the first repository at the Texas, Nevada or Washington sites to accommodate all the spent fuel reproduced by U.S. civilian reactors through 2020?

ANSWER: At both the Texas (Deaf Smith) and Washington (Hanford) sites, the repository would be located in thick, relatively flat formations. The Texas salt beds and the Washington basalt flows range from hundreds to thousands of square miles in area. Accordingly, it should be technically possible to expand the current reference repository design to accommodate all the civilian spent fuel produced through the year 2020. However, we have not characterized either site to the degree necessary to know, with confidence, the lateral continuity of the host rock. It is possible, that in characterizing the sites, we may encounter technical obstacles to establishing either the suitability of the sites or expanding the sites beyond present planning.

The Nevada site at Yucca Mountain is located in a block of volcanic tuff. This block would readily accommodate at least 70,000 metric tons of spent fuel. However, the site is bounded by faults and cannot be expanded unless the repository is extended northward, across a major fault zone. This northerly block of tuff has not been adequately explored; little is known about its suitability as a potential repository site. To gain the necessary information, approximately 2 to 3 years of surface-based exploration would need to be completed.

MRS

QUESTION 1: For the next few months little is likely to happen to fund construction of the MRS. So this is a good time to be refining and improving the analysis of MRS benefits and developing a better incentive package for Tennessee. What is being done?

ANSWER: The Department had completed the development of its MRS proposal including the detailed study of the need for and feasibility of the MRS and the site specific designs, and subsequently had printed these reports for planned submission to the Congress in February 1986. Since then the Department has been considering the comments and reports to identify areas where a better articulation or clarification of the benefits of the MRS to the overall waste system or to the host State and community may be able to assuage State concerns or make the benefits better understood.

QUESTION 2: What funds are now available to the MRS program? How are they being used? Is more money needed? Should we think about making funds available through a supplemental?

ANSWER: FY 1986 funds in the amount of $3,000,000 were made available to the MRS program. Funds have been used in preparation of the MRS proposal, and will be further utilized to provide institutional interactions to the State and local governments and to provide responses to the Congress. Cost estimates for the balance of the fiscal year indicate that no additional funds are required. However, if the MRS proposal is not acted upon within that timeframe and institutional activities are to continue beyond FY 1986, additional funding may be required.

QUESTION 3: What are the implications of a failure to get agreement to construct an MRS in Tennessee?

ANSWER: Failure to get agreement to construct an MRS at some site could potentially delay the facility's operational capability several years and thereby delay realization of several of the time-dependent benefits to be gained from the MRS. These include early development and operation of the transportation system and early acceptance of spent fuel from utilities. Regarding early acceptance of spent fuel, should an MRS be implemented as proposed by the Department and begin operations in early 1996, about 14,000 metric tons more of spent fuel could be accepted by 2003 (when the repository is expected to be operating at full scale acceptance rates).

Department of Energy
Washington, DC 20585

June 9, 1986

Honorable Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On April 29, 1986, James W. Vaughan, Jr., Acting Assistant Secretary for Nuclear Energy, appeared before the Energy and Natural Resources Subcommittee on Energy Research and Development to discuss the budget authorization for FY 1987 nuclear research and development.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Mike Gilmore or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Cathy J. Hamilton

for Robert G. Nabben
Assistant General Counsel
for Legislation

Enclosure

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

APRIL 29, 1986 HEARING

BEFORE THE

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

WITNESS: JAMES W. VAUGHAN, JR.

ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY

U.S. DEPARTMENT OF ENERGY

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 1: What is DOE's role in nuclear R&D?

a. Is it to resolve the near term problems of the light water reactors?

b. It it to lead the effort in finding the best technology that will be the most competitive in the next ten years, to assure the industry is viable, and marketable, here and internationally?

c. Is it to lead and set the direction the industry follows, or to follow the direction set by the industry?

d. Is DOE's role to assure an adequate power supply for the nation for the future?

Answer: The Administration's fifth National Energy Policy Plan provides a fivefold strategy to overcome the handicaps currently facing the nuclear option and ensure that nuclear power can continue to contribute to energy security, stability, and strength. The Administration's primary energy policy goal is to assure an adequate energy supply at reasonable costs. The elements of the Administration's fivefold strategy are:

- To reform the process of plant licensing and regulation legislatively--encouraging standardized plant design and

Answer 1
(continued): "one step" licensing that ensures safety, effective public participation, and environmental protection.

- To push ahead with the deployment of an integrated geologic disposal system for high-level radioactive waste, including plans for monitored retrievable storage (MRS), so as to meet the mandate to begin accepting nuclear spent fuel and high-level radioactive waste by January 1, 1998.

- To concentrate research and development (R&D)--with the full involvement of the private sector--on technology that can contribute to nuclear safety for current and next-generation light water reactors (LWR's), standardized plant designs, simplification of reliable operation, and advanced concept plants.

- To call public attention to the fact that the U.S nuclear industry is still the world's technology leader and that the outstanding safety record of today's U.S. plants originates in redundant protective mechanisms and unparalleled programs of training and vigilance.

- Finally, to remove unneeded barriers to foreign trade for the U.S. nuclear industry and to restore this country's

Answer 1 (continued): primacy in uranium enrichment services--in the interest of U.S. energy security, world energy stability, a better trade balance, and an even stronger international environment to resist the spread of nuclear weapons technology.

Efforts in nuclear energy R&D are directed to be complementary to those of the private sector. The emphasis in Federal R&D is on reactor safety and the early stages of the process of advanced reactor systems development, including applied research, proof-of-concept, and technology development. The marketplace will best identify and support the more promising options that meet market-driven criteria and needs for the future.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 2: This administration has said DOE's mission is to fund long-term research while those types of near term research are to be continued by industry. The funding focus of DOE's nuclear R&D program indicates that the trend is moving in just the reverse direction. Why is this?

Answer: The Department expects the private sector to take the lead financially and technically in nearer-term efforts and for the Government to take the lead in the longer-term R&D efforts. The Department is pursuing its traditional role in doing near-term light water reactor (LWR) safety-related activities and longer-term advanced reactor research and development (R&D). The Department's proposed FY 1987 program is consistent with this policy.

Our LWR efforts are complementary to those for which the private sector has assumed the lead. The industry funding contribution is several times greater than the Government contribution.

Within the Department's Nuclear Energy R&D budget, the funding for longer-term, high-risk efforts--including supporting facilities--is approximately seven times that for the nearer-term LWR efforts.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 3: The reduced funding to advanced reactors seems to indicate little effort will be directed to advanced reactors until light water reactors are improved. Isn't this effectively closing out the possibility of major advancements in the technology, such as the Integral Fast Reactor at Argonne National Laboratory?

Answer: The advanced reactor program's success depends on resolving key technology and regulatory issues. A key objective will be to achieve the level of inherent characteristics necessary to provide a passive shutdown of a reactor system and remove its decay heat without operator action and without reliance on complex "engineered" safety systems. Also, interactions with the U.S. Nuclear Regulatory Commission must verify that the new design and licensing approaches are feasible. Finally, additional economic analysis must be conducted to verify that perceived cost improvements are obtainable. Economic advanced reactor concepts cannot be designed or developed without these basic understandings in hand. The proposed FY 1987 advanced reactor research and development (R&D) program develops this information on a timely basis. The R&D work on metal fuels, which is critical to proof of principle for the Integral Fast Reactor concept, will continue to be supported within the Advanced Reactor R&D and Facilities categories of the Nuclear Energy research and development budget. Six million dollars of advanced reactor

Answer 3 (continued): R&D funds are planned to be utilized for metal fuel R&D. Additional support of this effort is available from the planned Argonne National Laboratory facilities budget.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 4: When will the ERAB review of DOE's Strategic Plan for Civilian Reactor Development be issued? How does the Department intend to incorporate the ERAB comments into its program plans?

Answer: The Energy Research Advisory Board (ERAB) reviewed and commented on its Civilian Nuclear Power Panel's report on DOE's draft Strategic Plan for the Civilian Reactor Development Program at its May 7, 1986 meeting. A final report has not been approved by ERAB for submission to DOE. Following consideration and incorporation of comments, the final report will be submitted to the Department. When received, the ERAB recommendations will be appropriately considered in the final, revised Strategic Plan being prepared by the Office of Nuclear Energy.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 5(a): The shift from civilian to military nuclear R&D could have vitally important international ramifications that will directly affect our nation. Internationally, the use of nuclear energy is growing and further growth is inevitable. The U.S. has clearly shaped and led the world in the responsible use of nuclear energy.

What will be the long-term international impact of the U.S. opting out of civilian development and applying its resources to military requirements?

Answer: The United States continues to pursue civilian nuclear power development. Research and development (R&D) on advanced civilian reactor concepts will be continued. The Department maintains a clear distinction between nuclear weapons development/production activities and nuclear power system R&D--the former funded as Atomic Energy Defense Activities while the latter is funded under Energy Supply R&D Activities. Any transfer of funds between these separate activities under the Energy and Water Development Appropriation would constitute a reprogramming action subject to prior Congressional approval. In FY 1987, our efforts within the civilian program regarding defense will be limited to determining the suitability of advanced civilian designs for defense applications, and vice versa.

Answer 5(a) (continued): Research and development on nuclear energy systems for both civilian and defense applications requires common expertise and similar test facility capabilities. Therefore, these programs are managed as an integrated activity.

Some of the Department's nuclear R&D facilities possess capabilities which can satisfy the testing requirements of development programs for both civilian and defense applications. Such testing has always been conducted in the same facilities, and the Department will continue this practice. The cost to do otherwise, i.e., to provide separate facilities for civilian and defense power system testing, would be prohibitive. Because this mode of managing our programs does not differ from past practice, there should be no international impact.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 5(b): A number of countries, forging ahead in nuclear R&D and nuclear marketing have challenged our lead in the nuclear energy market. Will not this shift further erode our nation's marketing capability?

Answer: Much of our R&D effort on light water reactors (LWR's) is focused on complementing industry efforts to advance the LWR option. When successful, this work will provide the basis for more successful international marketing and advanced LWR systems. In the advanced reactor development program, the Department's primary effort will remain focused on advanced civilian reactor concept development and supporting R&D with emphasis on competitive economics, passive safety, and improved licensability. To date, progress has been encouraging; projected costs appear to be competitive with LWR's and coal plants, innovative passive safety features have been designed and will be tested, NRC interactions to date have been positive, and plant availability estimates are high. We believe that these advanced designs will help provide a basis for the United States retaining its leadership role in the nuclear field.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 6: The civilian program is being seriously jeopardized by the diversion of funding to SDI while there is some question as to the how the research will be used by DOD.

What benefits will come to the continuing civilian reactor program as a result of military research efforts?

Military requirements for space reactors are specific and concern the reduction of size and weight of a reactor, and to the ability to achieve extremely high temperatures. The civilian reactor requirements appear to be quite the opposite, as size, weight, and high temperatures are not major concerns. Where is the connection between the two efforts?

Answer: The most applicable military applications would be those in the multimegawatt range of generating capacity for powering ground-based Strategic Defense Initiative (SDI) systems which General Abrahamson has recently indicated to be of interest. There is no current DOE study of this, since extensive information exists for this size range. The duty cycle required by these SDI systems places a premium on transient response and capability to rapidly power up for durations of a few minutes or longer depending on the power demand profile of the system. The engineering of transient response is comparable to the needs of load following central station units for civilian utility service.

The 10 megawatt electric (MWe) units are appropriate to command-control-communications-intelligence functions of SDI and the secure support power needs of Air Force operational

Answer 6 (continued): units. Such units, modified for civilian service, would be adaptable to industrial cogeneration or remote locations, particularly where total life cycle cost of power or fuel supply logistics dominate the selection process. Military experience will be important in the development of a market for civilian applications.

Space power requirements and technology applications are still under development within the SDI community. It is known that space and weight factors will be at a premium. These factors dictate emphasis on high temperature fuel, coolant and materials technology as well as light weight, compact shielding, and remote instrumentation and control concepts. All of these "space" technologies can benefit civilian power generating units. In addition, DOE's nuclear infrastructure is positioned to support the various defense and space efforts and at the same time will benefit from both the civilian and military/space programs.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 7: The absence of a specific mission for the SP-100 has troubled the Congress for some time. Notwithstanding the general interest of SDI in high power systems, what is being done in the program to further focus and develop the mission? How are the technical and testing requirements influenced by present uncertainties in user requirements?

Answer: A reference mission for SP-100 was established by the Strategic Defense Initiative Organization (SDIO) in September 1985. This mission is an early 1990's launch and space flight demonstration of a 300 kilowatt electric SP-100 space reactor power system driving one or more electric propulsion units for the SDIO. The reference mission serves to ensure proper focus to the ongoing SP-100 Ground Engineering System (GES) Development and Demonstration Testing program.

This planned flight demonstration would accomplish three objectives. First, it would demonstrate SP-100 as well as electric propulsion technologies in space. Second, it would flight qualify both SP-100 and electric propulsion systems, making them available for dedicated, ready use. Third, it would prove both the feasibility and utility of actually maneuvering platforms in space to enhance their survivability and offer an available means for their virtually unlimited spatial transfer.

Answer 7 (continued): Preliminary planning for this flight demonstration was initiated by SDIO in late FY 1985. Moreover, funding for this demonstration flight has been included in SDIO's outyear budget projections. SDIO's preliminary planning effort for this flight demonstration is now underway with several U.S. Air Force (USAF) and National Aeronautics and Space Administration (NASA) offices, laboratories, and contractors participating. A preliminary report of this planning effort, which involves scoping the activities, schedule, and costs associated with a 1993 target flight date, is expected in the summer of 1986.

In addition to the current flight demonstration planning activities, SP-100 mission analysis and requirements definition efforts continue to be conducted for military missions by the USAF (as an executing agent of SDIO), and for civilian missions by NASA. The status and results of these efforts will be periodically presented to the SP-100 Missions Advisory Panel, a top-level body representing both the civilian and military mission/user agencies. This panel will provide advice, counsel, and recommendations to the SDIO Space Power Manager from a missions, requirements, and users' perspective. Any changes to requirements impacting the design, development, or testing effort that are adopted as a

Answer 7
(continued): result of this process will then be immediately imposed on the SP-100 GES program.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 8: Many of the design requirements of the Multimegawatt Terrestrial Reactor Program (MTP) could be helpful in getting the power industry back on its feet; features of the reactor for the MTP program that could be used in the commercial nuclear power industry if it is ever to get back on its feet, such as walk-away safety, short development lead time, economic competitiveness, modularity, and simplicity. Is DOE focusing goals of its commercial power program on achieving the same capability now evolving from its military terrestrial power program? Is fiscal and programmatic synergism possible?

Answer: Any future commercial reactor system must have operating and capital cost competitiveness, must meet passive safety targets, and must be licensable in a predictable manner so utility executives can order new units with greater confidence. The Department has indeed focused its advanced nuclear power development program on these features over the last several years, e.g., conceptual design work for advanced liquid metal and high temperature gas systems. The Multimegawatt Terrestrial Powerplant (MTP) program provides a vehicle to demonstrate the nation's ability to apply these features to a real powerplant for which there is a defined need. Also, some of the development work done in the commercial sector and DOE's advanced nuclear power development program can be used in the MTP program; we expect this synergism to continue during the design and construction

Answer 8
(continued): of the MTP. The Department will attempt to obtain maximum possible technological synergism between the civilian power programs and all elements of its expanding defense nuclear energy program, particularly in the MTP project.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 9: Why is the multimegawatt program emphasizing technology development before a mission has been defined? What are the present requirements (power, lifetime, startup time, etc.) for each of the weapons systems planned? How do uncertainties in these requirements impact the technology advancement program needed?

Answer: The requirement for multimegawatt space power is tied closely to the President's Strategic Defense Initiative (SDI), which is a research program to determine the feasibility of a defensive shield which would make ballistic missiles obsolete. Power is an enabling technology for the SDI, and order of magnitude improvements in the current state-of-the-art will be needed. As a result, power system technology--whether it is ground-based, space-based, nuclear, or nonnuclear--is being pursued. Statements made by Lt. Gen. Abrahamson, Dr. Yonas, and Dr. Ionson from the Strategic Defense Initiative Organization (SDIO) before Congress clearly illustrate the need to pursue multimegawatt space nuclear power technology and the SDIO's commitment to this effort.

DOE has received $7.88 million in FY 1986 from the SDIO to carry out conceptual design studies on candidate multimegawatt nuclear power systems in support of weapons

Answer 9
(continued): requirements and to assess technology needs and conduct necessary analyses and component tests to establish technical feasibility and affordability of selected systems. In addition, the Defense Department is in the process of further refining the military requirement for multimegawatt space power. Documentation supporting that requirement is classified information. However, the broad range of SDI requirements can be grouped into three main operational modes, i.e., Housekeeping, Alert and Burst. In the "Housekeeping Mode" of operation, the power level required ranges from 0.1 to 1 megawatt electric (MWe), with a nominal 7 year life. In the "Alert Mode", the power level ranges from 2 to 20 MWe for intermittent operation with a 1 year integrated lifetime. For the "Burst Mode" of operation, the power level ranges from 100 to 1,000 MWe for times that range from 200 to 2,000 seconds. The startup times for these modes of operation range from 5 to 30 seconds.

For the Multimegawatt (MMW) program, as precise weapons requirements are known it will be necessary to pursue a few concepts and supporting technologies to ensure that, in making the orders-of-magnitude advancements in technology, at least one path will meet with success.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 10: How does the Department intend to fulfill its increased responsibilities under the Low-Level Radioactive Waste Policy Act Amendments of 1985, when in fact, the budget request for FY 1987 is down 13 percent compared to FY 1986 levels?

Answer: The Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240) assigns several new responsibilities to the Department of Energy (DOE). These include responsibility for disposal of "greater-than-class C" non-DOE low-level waste; management of an interest-bearing escrow account to rebate to unsited States and regions 25 percent of disposal fee surcharges where those States or regions meet certain developmental milestones; and the allocation of up to 800,000 cubic feet of disposal capacity among the three commercially-operated disposal sites for low-level radioactive waste generated by utilities as a result of unusual or unexpected operating, maintenance, repair, or safety activities.

In addition, DOE is required to prepare several reports for Congress, including (1) a report due in Janaury 1987 on how it will ensure the safe disposal of greater-than-class C low-level waste; (2) an annual report on (a) the progress of States and compact regions in developing new disposal capacity; (b) the practices of industry to manage, store, treat, ship and reduce in volume low-level radioactive waste;

Answer 10 (continued): and (c) projections for storage and disposal requirements for the following year; and (3) a report on how applicable States and regions expended the rebates from the escrow account of 25 percent of the disposal fee surcharges.

Finally, the Department is to provide assistance to States and compact regions to help them in developing new disposal facilities.

In FY 1986, the Department will establish the escrow account and develop procedures for (1) providing the appropriate disbursements to unsited States and regions or to the disposal site host States should the required milestones not be accomplished; and (2) allocating the 800,000 cubic feet of disposal capacity for utility-generated wastes from unusual or unexpected operating, maintenance, repair, or safety activities. The "greater-than-class C" low-level waste study will be conducted and the report to Congress is scheduled to be completed by January 15, 1987. The report on the expenditure of the escrow account funds will also be submitted to Congress in FY 1987. In FY 1987, the annual report required by Public Law 99-240 will provide an account of the progress States and regions made in 1986 to develop new disposal facilities and information about low-level waste shipped to disposal sites. The other features of the annual report on generator and industry practices will require time

Answer 10 (continued): to conduct comprehensive surveys and to expand our analytical and data base capabilities. This information will be included in future reports as funds permit and information can be obtained.

Finally, the Department has not requested funds to provide any new financial assistance to States or regions in FY 1987. The Department feels that Federal support of State and regional disposal facility development should be limited to the provision of information, technical assistance and the evaluation of improved technologies for treating, packaging and disposing of low-level waste. Technical information will be available to help States and compact regions plan and conduct each required phase of low-level waste disposal facility development according to the milestone requirements in the Act. The budget request contains adequate funds to carry out a limited support role for the States and regions as well as meet DOE's responsibilities under the Act as described above.

DOE believes that since the disposal of low-level waste is the responsibility of the States, compact regions and States should provide the funds to develop low-level waste disposal sites without relying on the Federal Government for further direct financial support. In separating the responsibilities of the States and the Federal Government, we believe that the

Answer 10
(continued): language of the Act also would encourage the States and compact regions to develop financially independent means for their low-level waste management activities.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 11: How much money is earmarked in the FY 1987 budget for decommissioning of the Power Burst Facility in Idaho? Will it ever be possible to resurrect this facility if it is later required to pursue as yet unidentified safety research goals?

Answer: The FY 1987 budget request includes $6 million under the Surplus Facilities Management Program (SFMP) to begin Phase I planning, documentation, and defueling of the Power Burst Facility (PBF). This will result by the end of CY 1988 in the PBF being placed in a "safe storage" condition pending Phase II decommissioning. Phase II will not begin until after 1992. Reactivation of the facility prior to final decommissioning should not be precluded by any Phase I defueling and inactivation.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 12: Can you give us some specific examples of the types of experiments carried out and facilities that DOD uses or will use to pursue its research needs with respect to military nuclear power concepts?

Answer: It is important to recognize that DOD does not directly use DOE facilities where experiments are conducted as part of interagency programs for which DOE is the executing agent. All of these programs are jointly funded and, in many cases, the technologies that are developed could be applicable to civilian as well as military use. Multiple purpose experiments have been and will be conducted in various facilities such as the Experimental Breeder Reactor II (EBR-II) and the Fast Flux Test Facility (FFTF) to characterize and evaluate the performance of fuels and materials for SP-100 and the multimegawatt space reactor in prototypic thermal and radiation environments, and in the Zero Power Plutonium Reactor (ZPPR) to determine nuclear reactor core characteristics. Future tests will be conducted in liquid metal test loops to confirm the performance of prototypic system components. The Plutonium Recycle Test Reactor (PRTR) containment building has been selected as the preferred facility for performance testing of the SP-100

Answer 12
(continued): Ground Engineering System reactor. Other facilities such as those for fuel fabrication, post-irradiation examination, and maintenance and assembly will also have dual use.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 13: How much does it cost to keep Oak Ridge in stand-by status? You mentioned the saving of $250 million between FY 86 and FY 91; that is $50 million per year in savings for shutting down Oak Ridge. But have you taken into consideration the unused power charge paid to TVA? Isn't it about $140 million/year?

Answer: The cost associated with keeping the Oak Ridge Gaseous Diffusion Plant in standby amounts to about $9 million in FY 1987. An additional $12 million will be required in FY 1987 for environmental monitoring, fire protection, guards, and other support necessary to keep the plant in standby.

Through the end of FY 1986, we expect to have saved about $62 million due to the plant being placed in a standby mode. At the time of the Secretary's announcement of June 5, 1985, it was estimated that about $9 million would be saved through the end of FY 1986. The additional $53 million that we expect to save by the end of FY 1986 is due the plant being placed in standby more quickly than originally planned. In FY 1987, we project that an additional $63 million will be saved, compared with $54 million estimated at the time of the Secretary's decision. Although the unused power at Oak Ridge is estimated to cost $205 million in FY 1986 and $213 million

Answer 13 (continued): in FY 1987, the costs would need to be borne whether Oak Ridge is operating or is in a standby mode. However, since the energy cost of purchased power is much lower at either Portsmouth or Paducah, over $30 million per year can be saved by purchasing lower cost power at these two sites, rather than from TVA at Oak Ridge.

QUESTIONS FROM CHAIRMAN PETE V. DOMENICI

Question 14: What are the new and innovative ways of operation you mentioned in improving the economics of operating the GDPs at Portsmouth and Paducah plants?

Answer: Traditionally, the gaseous diffusion plants have only used firm power; that is, the plants operated at fixed power levels and only infrequently were the power levels changed because to do so was slow and inefficient. Within the last 2 years, new operating methods have been developed which allow the plants to use unfirm power. Specifically, the plants now have the capability to efficiently change power within a time span as short as one-half hour. Two basic methods are now available to quickly increase and/or decrease power levels. Each plant has equipment called freezer/sublimers which allow the plants to quickly add or remove the process gas (UF_6) from the operating equipment. The second method is based on the plants' operating at only a fraction of their full power design levels. The process equipment which is off-stream is used as reservoirs to store UF_6 which can then be quickly added or removed from the operating equipment. In FY 1985, the use of unfirm rather than firm power saved approximately $6 million. To date in FY 1986, the savings have been about $1 million. Considerable amounts of unfirm power are expected to be used in the future.

QUESTIONS FROM THE MINORITY

Uranium Enrichment

Question 15(a): On page 53 of your statement you state that $235 million will be paid back to the Treasury in FY 1987 from uranium enrichment revenues and that $110 million will accrue in FY 1986.

Your FY 1986 estimate shows a net appropriation of $189.8 million. How can you be returning money to the Treasury? Are we just appropriating money so you can pay it back in?

Answer: The estimated $189.8 million net appropriation for FY 1986 is calculated by subtracting estimated revenue collections of $1,360.6 million from available appropriations of $1,550.4 million.

In calculating the return of money to the Treasury in FY 1986, the estimated revenue collection of $1,360.6 million is subtracted from estimated outlays of $1,250.6 million. Therefore, revenues in excess of outlays of approximately $110.0 million will accrue to the Treasury in FY 1986.

QUESTIONS FROM THE MINORITY

Uranium Enrichment

Question 15(b): How is your proposal for FY 1987 consistent with the Consolidated Omnibus Budget Reconciliation Act (COBRA) that set a payback goal of $150 million for FY 1987 provided this could be done consistent with the financial integrity of the program over the long term as well as reliability of supply at competitive prices to present and future customers?

Answer: The Administration is currently reviewing our FY 1987 enrichment budget and all of the provisions of Public Law 99-272, the Consolidated Omnibus Budget Reconciliation Act of 1986.

QUESTIONS FROM THE MINORITY

Uranium Enrichment

Question 16: In the Federal Register of January 29, 1986, you propose a new section 762.6 entitled "Recovery of Prior Unrecouped Government Costs". Shouldn't this be amended to be consistent with section 7502 of COBRA?

Answer: Section 762.6 of the proposed criteria and the remainder of the proposed rule are under review. Public Law 99-272, the Consolidated Omnibus Budget Reconciliation Act of 1986, will be considered in formulation of the final rule.

QUESTIONS FROM SENATOR J. BENNETT JOHNSTON

Question 17: Has the Reagan Administration given up on the future of civilian nuclear power in this country? You cut the nuclear energy budget by 12% overall and then cannibalize the reduced amount from the inside to support Star Wars. Of the $332.7 million request it appears that $243 million or 73% is for program aimed at Star Wars. What potential civilian application is there for the research this $243 million supports?

Answer: Only a portion of the $243 million directly relates to the President's Strategic Defense Initiative (SDI)--$66.7 million of our FY 1987 budget request under Nuclear Energy Supply R&D is directly related to SDI activities; $49.5 million for Advanced (civilian) Reactors and $121.8 million for the operation of DOE's facilities only partially relate to SDI. The facilities are used for all DOE nuclear programs as well as the Nuclear Regulatory Commission and others (such as foreign exchange programs). No apportionment of these costs has been made.

The intellectual and experimental capabilities of the civilian nuclear energy research program, including industry, national laboratories, and universities, are the strongest in the world. Nuclear power systems and their associated power generating, conditioning, and control technologies under consideration or development for SDI depend on this expertise and test capability for performance of the needed work. However, this expanded use of highly qualified scientists

Answer 17
(continued): and engineers to meet the needs of SDI should not be interpreted as an abandonment or phase-out of the civilian nuclear energy research program or its goals.

Additionally, operational requirements of SDI systems, particularly in the areas of transient response, reliability, survivability, and control, will almost certainly benefit civilian nuclear energy systems.

The principal area of interface is application of common technology such as liquid metal systems, fuels and materials, and control systems. The most appropriate military applications are those in the multimegawatt range of generating capacity for powering ground-based SDI and other military systems. The duty cycle required by these systems places a premium on transient response and capability to rapidly power up for durations of a few minutes or longer depending on the power demand profile of the system.

The 10 megawatt electric (MWe) reactors, planned for military bases, are appropriate to command/control/communications/ intelligence functions of SDI and the secure support power needs of Air Force operational units. Such reactors,

Answer 17
(continued): using modular construction techniques and passive safety systems, could be adaptable for applications such as industrial cogeneration or power for remote locations, particularly where total life cycle cost of power or fuel supply logistics dominate the selection process. Experience in the nearer term applications to military bases will be important in the development of a market for civilian applications.

Space power requirements and technology applications are still under development within the SDI community. It is known that size and weight factors will be at a premium. These factors dictate emphasis on high temperature fuel, coolant, and materials technology as well as on light weight, compact shielding, and remote instrumentation and control concepts. Some of these "space" technologies may benefit civilian power generating units. In addition, the nuclear power infrastructure in both our national laboratories and in segments of the private sector is positioned to support the various defense and space efforts. This infrastructure can benefit from both the civilian and military/space programs by maintaining a cadre of qualified scientists and engineers.

QUESTIONS FROM SENATOR J. BENNETT JOHNSTON

Question 18: How much of your nuclear energy budget is actually for Star Wars research? How does this compare with last year's appropriations? With last year's budget request?

Answer: In the 1987 budget request, $71.7 million was requested for Space/Defense Nuclear Power Systems. This includes the tri-agency SP-100 space power program that will provide power for Strategic Defense Initiative (SDI) space platforms; the Dynamic Isotope Power System (DIPS), which will provide the Air Force's Boost Surveillance and Tracking Systems (BSTS) for SDI and other Air Force needs; the Multimegawatt Terrestrial Powerplant (MTP) for Air Force bases and logistic centers (in which there is also some SDI interest); and the Multimegawatt (MMW) Space Power Reactor, which is primarily for SDI but which may have future civilian applications as well. Direct SDI research is a major focus of Space/Defense Nuclear Power Systems activities. This research will also have applicability to civilian and other military missions. In addition, some of the overall DOE facilities operating cost is in support of these defense nuclear energy projects.

The FY 1987 request of $71.7 million compares with $20.2 million appropriated in FY 1986. This previously

Answer 18 (continued): planned and projected increase in FY 1987 is due to the movement of several projects toward advanced design and hardware production, which requires greater funding than the more preliminary design and research activities conducted in FY 1986, and to the need to support these development efforts on a time scale that is compatible with overall SDI program requirements.

For example, the SP-100 is moving from feasibility studies into Ground Engineering System (GES) development that would support proceeding into a reference flight mission in the early 1990's. The Dynamic Isotope Power System and Multimegawatt Space Reactor Program will also be proceeding into the development phase, as opposed to initial conceptual studies conducted previously with user funding; the Multimegawatt Terrestrial Powerplant will also be entering a more advanced design phase. The FY 1987 budget request is necessary to support these activities as they move forward into development; the FY 1986 level, if continued into FY 1987, would be insufficient for this purpose. In summary, the increase from FY 1986 to FY 1987 reflects an orderly transition of research activities into further stages of development.

QUESTIONS FROM SENATOR J. BENNETT JOHNSTON

Question 19: The largest increase in your budget request is for Space and Defense Power Systems which would more than triple from $20.2 million to $71.7 million. Why is this huge increase necessary and what would it be spent on?

Answer: The Space and Defense Power Systems program is comprised of five projects: the SP-100 and Multimegawatt (MMW) Space Reactor Projects; the Multimegawatt Terrestrial Powerplant (MTP) Project; the Small Nuclear Power Source Demonstration Project; and the Dynamic Isotope Power System (DIPS) Project. Although the Department's FY 1987 budget request for this program has increased from $20.2 million in FY 1986 to $71.7 million in FY 1987, this increase is neither unanticipated or inappropriate. Each of the five projects, with one exception, has progressed to a new stage, bringing each closer to becoming "hardware" and, therefore, requiring more funds for design or development. The only exception is the Small Nuclear Power Source Demonstration Project, wherein the Department's planned contribution to this joint project decreases from FY 1986 to FY 1987 due to the winding down of the development program and to actual delivery and testing of a demonstration reactor.

Answer 19 (continued): Each of the five projects is jointly funded through agreements with the Department of Defense (DOD) and is responsive to DOD requirements. In all cases, cooperative funding is provided by DOD which, in FY 1987, generally matches or exceeds requested Department of Energy (DOE) funds. Specifically, whereas the total DOE funding request for the five Space and Defense Power Systems projects for FY 1987 is $71.7 million, the DOD funding for those same projects totals $92.5 million.

For example, the SP-100 program, which was funded in FY 1986 by DOE at $16.0 million and by DOD at $15 million, has now completed its technology assessment and advancement stage. We have selected a design concept and a preferred site for testing, and have received responses on a Request for Proposals for detailed design and engineering development. In the new Technology Readiness phase now underway, construction and ground testing will commence over the next 5 years on a prototypical space reactor and its power conversion subsystem. The advanced design work leading to construction and preparation for ground testing starting in FY 1987 will require more funds than the technology development activities that were conducted in FY 1986. Consequently, the DOE funding request has increased from

Answer 19
(continued): $16.0 million to $30 million. The corresponding DOD cost-shared contribution for FY 1987 is $50 million.

A similar scenario of project growth and transition applies to the DIPS, MTP, and MMW projects, resulting in the overall program funding increase discussed above. Also contributing to this increase in the Space and Defense Power Systems program is the issue of timing. If (1) the SP-100 reactor power system is to be available and proven by the early to mid-1990's as desired by DOD; (2) we are to be in a position to select one multimegawatt space reactor concept by 1991; and (3) we are to build a first Multimegawatt Terrestrial Powerplant within the 5 to 7 years desired by the Air Force, then certain activities must be conducted now and the funding DOE has requested in FY 1987 is necessary to conduct those activities and maintain the schedule commensurate with DOD's needs as the prime user.

QUESTIONS FROM SENATOR MALCOLM WALLOP

Question 20: Please describe for the Committee the details of DOE-funded nuclear research and development programs and activities in the international field, such as nuclear cooperation with other countries or groups of countries, with private or government-backed research institutes in any foreign countries or with foreign individual scientists, either indirect or direct. Please include exchange programs and DOE-funded IAEA programs. (You may exclude from your answer the Canadian/American cooperative pilot program for a nuclear powered battery for the DEWLINE early warning system, already covered in your testimony). But please do include DOE-funded uranium enrichment services provided to foreign countries and describe any DOE contracts in effect to provide such services to foreign countries.

Answer: DOE maintains an active international nuclear cooperation program in the areas of advanced reactor technology and safety. These programs are in some cases cost-shared and in other cases are paid for entirely with foreign funds. A listing of international programs is attached.

DOE also supports IAEA activities, with special attention to developmental work and research and development related to international safeguards. Key activities include:

- o U.S. involvement in IAEA's safeguards program, funded at about $5 million for FY 1986, which includes funds for

Answer 20
(continued): the development of safeguards equipment, approaches, instrumentation, training, etc.

- o Administering State Department funds (over $10 million for CY 1986 activities) which are applied to a number of areas, e.g. training, payment for providing expert services of scientists, participation in international technical working groups, fellowships, and the U.S. Program for Technical Assistance to Safeguards (POTAS). DOE expects a similar transfer of funds in CY 1987.

- o Small and Medium Power Reactor program, for which DOE provided a $15,000 contribution in 1984 and for which it has also provided expert services.

- o DOE has granted monies to the IAEA's Trieste Center for Theoretical Physics to assist the Center's program for visiting American scientists (most recent amount was $50,000).

With respect to DOE-funded uranium enrichment services provided to foreign countries, DOE supplies enriched uranium for research reactors abroad through commercial sale arrangements. Additionally, DOE implements the provision in Section 54 of the Atomic Energy Act that permits a gift of

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Answer 20
(continued): enriched uranium to be made annually through the IAEA, within an express ceiling value of $50,000. The most recent gift (1985) is being applied to Thailand.

CURRENT COOPERATIVE AGREEMENTS*
(Glossary of Acronymns at end)

Agreement/Projection Description	Foreign Entity	U.S. Facility
United Kingdom (Breeder)		
1) Austenitic Steel Swelling Studies	UKAEA	HEDL/FFTF
2) Ferritic Steel Swelling Studies	UKAEA	HEDL/FFTF
3) PFR/TREAT Fuel Testing	UKAEA	INEL/TREAT
Japan (Breeder)		
1) Operational Reliability Testing of Fuel	PNC	ANL, W, GE, HEDL, INEL, EBR-II
2) Neutron Calibration Device for MONJU	PNC	ANL
3) Transient Code Development	PNC	W
4) Reliability Data Base (CREDO)	PNC	ORNL
5) Reactor Shielding Tests	PNC	ORNL/TSF
6) Creep Rupture Testing of MONJU Materials	PNC	HEDL/FFTF
7) MONJU Fuel Testing	PNC	HEDL/FFTF
8) MONJU Tag Gas Capsule Design	PNC	HEDL
9) Fuel Cycle Criticality Experiments	PNC	PNL, LANL
Switzerland		
1) Carbide Fuel Tests	EIR	LANL
2) Carbide Fuel Tests		HEDL/FFTF

Italy (Breeder)		
1) Licensing Support for PEC Fast Reactor	ENEA	ANL
FRG (Breeder)		
1) SNR-300 Safety Calculations	BMFT	ANL
FRG (Thermal Recycle)		
1) Spent HTGR Fuel (U/Th) Treatment	BMFT	GA
France (Research Reactor)		
1) Reduced Enrichment Research Reactor Fuel	CEA	ANL

Glossary of Acronymns

BMFT	-	German Ministry for Research and Technology
CEA	-	French Atomic Energy Commission
EIR	-	Switzerland's Federal Institute for Reactor Research
ENEA	-	Italy's National Commission for Research and Development of Nuclear and Alternate Forms of Energy
FFTF	-	Fast Flux Test Facility (400 MWt)
MONJU	-	Japan's 300 MWe Demonstration Fast Breeder Reactor
PEC	-	Italy's Fast Experimental Reactor (120 MWt)
PFR	-	UK's Prototype Fast Reactor (250 MWe)
PNC	-	Japan's Power Reactor and Nuclear Fuel Development Corporation

* Nuclear waste agreements included in next response.

Questions from Senator Malcolm Wallop

Question 21:

Please describe in detail DOE-funded or partially funded programs with foreign countries in nuclear waste disposal R & D, including exchanges, research, visits, technical assistance, whether direct or indirect. Please provide budget break-downs on all such programs.

Answer:

The Department of Energy participates in radioactive waste disposal R&D programs under formal international agreements with Belgium, Canada, the Commission of the European Communities (CEC), France, the Federal Republic of Germany (FRG), Japan, Sweden, Switzerland, the United Kingdom (UK), and the Nuclear Energy Agency (NEA). These agreements provide for exchange of information; visits and assignments of scientists and engineers; exchange of samples, materials, instruments, and components for testing; seminars and other meetings; and joint projects in which the parties share the work or costs.

Cooperation with Belgium is currently limited to exchange of reports and short-term visits, primarily to the Belgian underground research laboratory at Mol. Funding for these activities, primarily staff labor and travel, is not broken down by country.

With Canada, the Department's efforts are concentrated on a joint project to exchange technology and performance assessment codes at the Canadian crystalline rock underground research laboratory at Whiteshell, Manitoba. The U.S. portion of this joint project is funded at $3,489,000 for FY 1986.

With the Commission of the European Communities (CEC), the Department's efforts are limited to exchange of reports and short-term visits. Funding for these activities, primarily staff labor and travel, is not broken down by country. The Department's agreement with the CEC is valuable in providing improved access to the reports and data from CEC-sponsored research programs undertaken in CEC-member states.

With France, the Department has an extensive program of visits, seminars, and exchange of documents. Funding for these activities, primarily staff labor and travel, is not broken down by country.

With the Federal Republic of Germany, the Department also has an extensive program of visits, seminars, and exchange of documents. The Department also participates in brine migration experiments in salt deposits at the Asse Salt Mine near Hanover, where the Department had supplied some equipment earlier, but no funds are planned for FY86. Currently, the funding for these activities, primarily staff labor and travel, is not broken down by country.

With Japan, the Department's efforts are currently limited to exchange of reports and short-term visits. Funding for these activities, primarily staff labor and travel, is not broken down by country. A more comprehensive radioactive waste management agreement with the Japanese is currently under negotiation.

With Sweden, the Department is participating in radioactive waste isolation experiments in the Stripa Mine waste repository in central Sweden under the aegis of the Nuclear Energy Agency, and plans to participate in the

underground spent fuel storage basin (CLAB) now nearing completion. The Department's participation in the Stripa project is funded at $385,000 for FY 1986.

With Switzerland, the Department's efforts are currently limited to exchange of reports and short-term visits, with emphasis on experiments at the Grimsel Pass underground research laboratory in the Alps. The funding for these activities, primarily staff labor and travel, is not broken down by country.

With the United Kingdom, the Department's efforts are currently limited to exchange of reports and short-term visits. The funding for these activities, primarily staff labor and travel, is not broken down by country. The Department is currently negotiating a comprehensive radioactive waste management agreement with the UK Atomic Energy Authority.

The Department participtes in several Nuclear Energy Agency (NEA) waste disposal R&D programs. These include the Stripa Mine experiments described above in the paragraph on Sweden, the NEA Seabed Working Group which is studying the feasibility of subseabed disposal of radioactive wastes, and the ISIRS project to develop a computer data base for storage of the results of radionuclide sorption experiments performed in NEA countries. FY 1986 funding for the Stripa project, as noted above, is $385,000, and for the International Sorption Information Retrieval System (ISIRS) Project is up to $5,000. Funding for the US Subseabed Program for FY 1986 is proposed at $7.2 million, of which a portion is allocated to the NEA Seabed Working Group activities.

4

The primary benefit of the foregoing cooperative activities is to enable the Department to gain more comprehensive and more rapid access to foreign technology. In addition, by task-sharing we can economize on resources so that each cooperating country can accomplish its research objectives at less cost or can achieve greater results for the same total expenditure.

The Department also provides technical assistance to the following non-nuclear weapons states in the field of spent fuel storage and disposal pursuant to Section 223 of the Nuclear Waste Policy Act of 1982: Botswanna, Brazil, Egypt, Indonesia, Italy, South Korea, Mexico, Netherlands, and Taiwan. Funds allocated for this activity in FY 1986 are planned at $125,000.

Questions From Senator Malcolm Wallop

Question 22:

Please provide figures and descriptions on visits of foreign scientists and others to DOE-funded facilities or facilities where DOE R and D programs are in progress. Give breakdowns of these visits and visitors by nationality and category of visit. Example: how many DOE facilities where R&D activities and programs are in progress were visited in FY 86 by persons, group or other entities from the Soviet Union? From the east-Bloc? From Israel? Who pays for the travel and per diem and how much did it cost? Were U.S. nationals given similar access, briefings or exchanges with the R and D being pursued in those countries?

Answer:

The Department of Energy, during the course of a year, is estimated to have more than 15,000 foreign nationals on unclassified visits or on unclassified longer-term assignments at DOE facilities. Of this total an estimated 75 percent are visits, a day to around two weeks, and the balance are assignments, during which these foreign scientists or technicians may work at DOE facilities under a formal agreement for up to two years.

Some foreign nationals are employed by DOE contractors for periods of months or more to work on DOE projects. Others are sent by their governments to visit or work. Foreign nationals hired to work on behalf of DOE are of course paid entirely from U.S. government sources. Pay, travel, and per diem of foreign nationals visiting or on longer-term assignments to DOE facilities on behalf of their governments are usually paid by the sponsoring government, although occasionally a stipend is provided.

Reciprocity and mutual benefit are the primary objectives in DOE's international energy R&D cooperation. With some countries, however, such as Yugoslavia and China, foreign policy interest is a significant component of our cooperation. Program managers of DOE programs are charged with insuring that reciprocity is observed in our international R&D cooperation programs. In our experience, such reciprocity is generally attained. With the Soviets, for example, we have scrupulously managed the quality and benefits of our exchanges, and we are confident that they are well balanced.

DOE is currently developing a fully automated central information management system to account for all foreign nationals who come to DOE facilities; until that is available approximations are possible for most facilities. Foreign nationals coming to DOE facilities are predominantly from Japan, the UK, France, or Germany. For China, the USSR, the East Bloc, and Israel, the following are the approximate numbers of foreign nationals involved in visits or assignments to principal DOE facilities in 1985.

VISITS (V) AND ASSIGNMENTS (A) TO DOE R&D FACILITIES
BY CITIZENS OF SELECTED COUNTRIES IN 1985

		USSR	East Bloc	PRC	Israel
Argonne National Lab.	V	2	23	57	13
	A	0	13	32	12
Brookhaven National Lab.	V	13	14	71	0
	A	0	22	71	18
Fermilab	V	4	1	0	0
	A	4	5	16	1
Idaho Nat'l Eng. Lab.	V	0	6	10	0
	A	0	0	0	1
Los Alamos Nat'l Lab.	V	11	13	7	9
	A	1	2	3	6
Lawrence Berkeley Lab.	V	2	1	1	0
	A	1	13	87	17
Lawrence Livermore Nat'l	V	24	5	9	5
	A	0	1	0	1
Oak Ridge Nat'l Lab.	V	20	10	27	0
	A	0	0	13	13
Solar Energy Res. Inst.	V*				
	A	0	0	4	0
Stanford Linear Accelerator Center	V*				
	A	0	2	64	9
Sandia Nat'l Lab.	V	0	3	0	0
	A	0	0	0	0
Savannah River	V	3	0	8	11
	A	0	1	2	0
Total	V	79	76	190	38
	A	6	78	292	78

*Data not available

Questions From Senator Malcolm Wallop

Question 23:

How many Soviet or east-bloc persons visited DOE facilities last year where R and D research is being conducted? Under what Under what auspices? How funded? Have any such persons had access to or visited or held discussions with DOE in the world's most advanced AVLIS enrichment technology program or in the Laser Demonstration Facility? Did any other foreign nationals visit, tour, discuss or otherwise have contact with this DOE R and D program and what countries were involved?

Answer:

DOE records indicate that in 1985, 79 Soviets visited DOE R&D facilities for unclassifed visits, and 6 for unclassified longer-term assignments. There were 76 such visits and 78 assignments of East Bloc persons, and 190 visits and 78 assignments for nationals of the PRC. These visits and assignments resulted primarily from agreements in energy cooperation with DOE, or from the employment by DOE facilities of these foreign nationals. They were generally funded by their governments, or paid as employees of the DOE contractor. None of these persons visited or had discussions with DOE in the AVLIS enrichment technology program or the Laser Demonstration Facility. In the past year foreign visitors to these facilities have been limited to a delegation of four Japanese nationals, who by arrangement with DOE toured the unclassified AVLIS and Laser Demonstration Facility and had unclassified discussions with U.S. experts.

QUESTIONS FROM SENATOR MALCOLM WALLOP

Question 24: How much did it cost DOE to terminate the GCEP project? Was any technical investment made in that program been salvaged? Your testimony gives an aggregate loss of $2.589 million. Please provide a breakdown of those losses.

Answer: The present estimate for termination of the GCEP project is $2,533 million, down from the earlier estimate of $2,589 million. At this time, alternative uses of the technology and the facilities are being pursued. There is considerable interest in the use of the centrifuge technology for flywheels and separation of isotopes other than uranium. A breakdown of GCEP costs follow:

GCEP COST BREAKDOWN
($ in Thousands)

	ITEM COST	TOTAL COST*
Engineering, Design and Inspection	$	$ 483,000
Land and Land Rights		225
Construction Costs		1,694,000
(1) Improvements to Land	45,000	
(2) New Buildings and Additions	495,000	
(3) Building Modifications	49,000	
(4) Special Facilities (Includes Centrifuges)	1,003,000	
(5) Other Structures	44,000	
(6) Outside Utilities	58,000	
Standard Equipment		21,000
Subtotal		$2,198,225
Technical Support		318,000
Other Activities		16,839
TOTAL		$2,533,064

Plus termination costs estimated at $222 million.

* Includes costs through June 30, 1985. Excludes operations, equipment, and research and development costs.

QUESTIONS FROM SENATOR MALCOLM WALLOP

QUESTION 25a: Please brief the Committee on the status of the People's Republic of China proposal for an international nuclear waste disposal program in the Gobi Desert.

Answer: Since early 1984 the Chinese Nuclear Energy Industry Corporation (CNEIC) has offered "to take unlimited amounts of spent fuel elements from European utilities up to 2010 for ultimate storage and possible future reprocessing without any obligations for the utilities to take back reprocessed uranium, plutonium or waste." [NUKEM Market Report 11/85, NUKEM GmbH, Hanau, FRG] The CNEIC is represented in dealings with the West European utilities by a consortium named Internuclear, formed by three West German companies.

In March 1984, the CNEIC made an offer to Austria to take spent fuel from the Tullnerfeld power station. Because of public opposition, it is probable that the Tullnerfeld plant will never be allowed to operate, so there is no real incentive for the Austrians to negotiate further at this time.

As of December 1985, the Chinese were reportedly still anxious to accept foreign spent fuel as part of their efforts to maximize foreign currency earnings. They had set a price of $1512 per kg of

spent fuel and were asking that any one agreement cover at least 1000 t. West German utilities were negotiating to send 150 tonnes of spent fuel to China, to test the system. The Germans are trying to arrange an exchange of one or more German-built nuclear plants for the Chinese spent fuel disposal service. [Nuclear Engineering International, December 1985, p. 25]

QUESTIONS FROM SENATOR MALCOLM WALLOP

QUESTION 25b: Has that program affected ours? Has it drawn away our foreign customers?

Answer: We see no evidence that the Chinese initiative has affected the U.S. nuclear program or drawn away any of our foreign customers, but it could reduce the prospects of U.S. nuclear trade with the PRC if the German effort to exchange nuclear plant for spent fuel disposal succeeds.

QUESTIONS FROM SENATOR MALCOLM WALLOP

QUESTION 25c: Is there any reason to suspect the Chinese could use the stored waste for reprocessing activities to make plutonium to make bombs?

Answer: China apparently intends to reprocess any foreign fuel they receive in this program. The country is developing a fast breeder reactor and may have use for plutonium breeder fuel early in the next century.

QUESTIONS FROM SENATOR MALCOLM WALLOP

QUESTION 25d: Have the PRC Chinese visited, toured or otherwise had access to DOE R and D waste disposal facilities and programs?

Answer: Many PRC students are studying at U.S. universities; we have heard that a few of them are interested in U.S. waste management technology. They no doubt have access to unclassified DOE technical reports. Visits of PRC scientists and engineers to DOE sites, seeking access to DOE waste disposal facilities and programs, have occurred infrequently. The last such visit to Hanford, by the director of a PRC unclassified research institute, occurred in June 1984. Visitors to Hanford in 1982 exhibited a good knowledge of the U.S. waste treatment program, particularly in the area of high-level-waste vitrification research.

QUESTIONS FROM SENATOR MALCOLM WALLOP

Question 26A. Please describe DOE plans for fusion energy R and D with Japan, with the EEC and with the Soviet Union. Please be as specific as possible on all these programs.

Answer: International collaboration in magnetic fusion energy research is necessary in order to achieve the program's goal in a timely fashion. The specific details on our plans to achieve the necessary degree of collaboration are contained in the attached report, International Program Activities in Magnetic Fusion Energy (DOE/ER-0258), prepared at the request of the House Appropriations Subcommittee on Energy and Water Development.

Department of Energy
Washington, D.C. 20585

April 1, 1986

Honorable Tom Bevill
Chairman, Subcommittee on Energy
and Water Development
Committee on Appropriations
House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

I am providing in this letter the response to the request by the House Appropriations Committee for a plan for international collaboration in magnetic fusion energy. The Committee made this request in its Report on the FY 1986 Magnetic Fusion Energy budget. I believe that international collaboration is an important factor in research. It is certainly important in the fusion energy field and has been a major factor in making effective progress for over thirty years, increasingly so in the last few years.

In support of the Department's Magnetic Fusion Program Plan, the Office of Fusion Energy has developed a strategy for international activities which incorporates recommendations in this area by both the National Research Council of the National Academy of Sciences[1] and the Department's Energy Research Advisory Board (ERAB).[2] The strategy is to conduct early joint planning with the other major programs, then to select and implement specific tasks for collaboration that would likely result in either significant enhancement of technical progress or significant reductions in overall cost and time or both. The overall policy context for the strategy is provided by the National Energy Policy Plan, which reflects the Department's positive view of international collaboration in energy research activities. The enclosed document, International Program Activities in Magnetic Fusion Energy, elaborates upon the strategy and provides a statement of direction and intent.

Governmental involvement in encouraging international activities among the major programs has come from both the Economic Summit and recent Geneva Summit. As part of the Economic Summit process, I have been personally involved in developing a policy framework to support enhanced collaboration. Joint discussions on possible collaborative efforts by the members of the Economic Summit Working Group on Controlled Thermonuclear Fusion are continuing. This Working Group recently reached a consensus on the nature and timing of the major facilities and development efforts required to

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[1] National Research Council Report, "Cooperation and Competition on the Path to Fusion Energy," 1984.
[2] Energy Research Advisory Board Report, "International Collaboration in the U.S. Department of Energy's Research and Development Programs," December 1985.

establish the feasibility of fusion and identified the medium-term goal, an Engineering Test Reactor (ETR), of a possible collaborative program. Key elements in the consensus are that: (1) joint design, construction, and operation of an ETR is a reasonable objective for international collaboration, (2) the breadth of the overall fusion program needs to be maintained through strong scientific and technical programs within each of the participants, and (3) within these individual programs, there are sizeable projected efforts, supportive to the ETR, such as a compact ignition device, and technological developments that could also be the object of international cooperation on an ad-hoc basis.

If the consensus is supported by subsequent Governmental discussions, it will probably take a few years for this planning effort to develop into detailed agreements for action that constitute a detailed multinational plan for fusion development. Such a plan would require the assent of many nations, including the U.S. The enclosure provides considerable detail on our current activities, strategy, and near-term expectations as we work toward the broader, multinational plan.

If you have detailed questions, please direct them to Dr. J. F. Clarke, Associate Director for Fusion Energy, Office of Energy Research.

Sincerely,

James F. Decker for

Alvin W. Trivelpiece
Director, Office of
Energy Research

Enclosure

cc:
Honorable John T. Myers
Ranking Minority Member
Subcommittee on Energy & Water Development
Committee on Appropriations
House of Representatives
Washington, D.C. 20515

DOE/ER-0258

INTERNATIONAL PROGRAM ACTIVITIES IN MAGNETIC FUSION ENERGY

March 1986

International Programs

U.S. Department of Energy
Office of Energy Research
Office of Fusion Energy
Washington, D.C. 20585

INTERNATIONAL PROGRAM ACTIVITIES IN MAGNETIC FUSION ENERGY

OFFICE OF FUSION ENERGY
Prepared by International Programs

POLICY

The policy on international collaboration in fusion has been formulated at the most senior governmental levels. The Economic Summit designated magnetic fusion as an area of technology appropriate for collaboration. The establishment of the Economic Summit Working Group on Controlled Thermonuclear Fusion under the Working Group on Technology, Growth, and Employment as the vehicle to implement the broad planning function was a direct result of the Versailles Economic Summit Meeting. Cooperation in magnetic fusion was also strongly and specifically supported by President Reagan at the Geneva Summit. The National Energy Policy Plan encourages international collaboration for energy research. The Department's Magnetic Fusion Program Plan integrates these various Governmental and Departmental positions into the fusion-specific plan.

The goal of the magnetic fusion program is to establish the scientific and technological base required for fusion energy. **The strategy in the Magnetic Fusion Program Plan (MFPP) to achieve this goal is to address the four key technical issues remaining in fusion: 1) Magnetic Confinement Systems, 2) Properties of Burning Plasmas, 3) Fusion Materials Development and 4) Fusion Nuclear Technology, with a strong, domestic program focusing on the basic elements and subsystems of fusion.** The MFPP calls for international collaboration in the four key technical issues as a resource necessary for the successful achievement of the goal in a timely fashion. Every major element of the U.S. fusion program is affected by international activities and in many of them there is an interdependence with other programs. This use of international collaboration is motivated by the confluence of four factors: budget pressures on the U.S. program, reduced urgency for deployment of fusion reactors, the technical challenge of fusion science and technology, and the highly talented people and unique research facilities in the foreign programs. As a result, the objectives of U.S. international collaboration are to share the many high priority tasks, to reduce the total costs associated with the required major facilities and to combine intellectual forces in pursuit of the most essential problems.

BACKGROUND

The U.S. fusion program has had three decades of successful international cooperation based on exchanges of information through topical workshops and personnel assignments. In recent years, this interaction has evolved to include a growing amount of collaboration, meaning effective use of and reliance on joint work with other programs. There are now over 20 agreements in place covering most major aspects of fusion activity.[1]

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1) Attachment 1 - Current U.S. International Activities in Fusion

Cooperation occurs principally among the four major programs, i.e., U.S., U.S.S.R., European Community (EC) and Japan, each having comparable strengths and capabilities. Collaboration takes place through formal agreements involving the U.S., EC and Japan; in each program, there are participants from national laboratories, universities and industries.

While there is general agreement among the major fusion programs on the key issues, there are differences in approach, facilities, emphasis, and motivation. There are also differences in the priority for collaboration, which must be considered while pursuing international initiatives.

STRATEGY

The strategy to achieve the international program objectives is to conduct early joint planning with the other major programs, then to select and implement specific tasks for collaboration that would likely result in either significant enhancements of technical progress, or significant reductions in overall cost and time or both. The significance of a task can be judged in comparison to a solely domestic effort to achieve a particular need.

A strong domestic program supporting our national interests is a prerequisite for successful collaboration. Our program assets are innovative, skilled personnel, fusion research laboratories, strong university research activities and specialized facilities. The investment in these assets can be protected and enhanced through international involvement.

STRATEGIC CONSIDERATIONS AND CONCERNS

Four strategic considerations underlie successful collaboration. The first is the existence of areas of technical need in which the other Parties have considerable technical strength or in which we have valuable capabilities. The second is a mechanism for regular, early joint planning in those areas having common, high priorities. The third is a mutual interest in and motivation for collaboration. The fourth is the capability for sustained budget and personnel commitment. With these four considerations satisfied, the Parties can enhance program complementarity by sharing priority tasks involving key issues.[2]

There are also three specific concerns which are included in the evaluation of each proposal to collaborate. First is the assurance of equity. A prerequisite for any fusion collaboration is a judgment of programmatic equity by the program officials from the involved Parties. Second is

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2) Attachment 2 - Complementarity of Program Elements Pursued by US, Japan and EC

control of selected technology information. On a case-by-case basis, each proposal must be examined for its economic and national security sensitivities and a determination of impact and appropriate mitigation procedures made before proceeding. Third is industrial involvement. Industries are invited to participate in the activities, and reciprocity is sought in the access to fusion information for and from industrial participants.

DOMESTIC PROGRAM IMPLICATIONS

Domestic program decisions are already being made in a more internationally oriented context. An international option is a key element in the evaluation process to determine research priorities and specific tasks.

Plans for the use of international activities evolve during this evaluation process. They begin at the technical working level as part of the exploration of common technical interests. They then proceed to the program level for broader integration into the national program. Following a programmatic determination of necessity and appropriateness, they are developed into formal intergovernmental agreements.

In parallel, higher priority is being given in the U.S. program to the management and evaluation of international activities to assure that full value is obtained for this increasing investment of personnel and hardware resources. In the near term, management decisions on issues such as priorities and balance will be more difficult due to the broader range of options opened by the possibility of international collaboration. As a result, greater effort will be required in the U.S. fusion community to develop even more creative technical ideas. In the longer term, the overall program should benefit from the ability to plan its new steps on the widest technical base possible.

IMPLEMENTATION

The formal mechanisms for international collaboration are in place or being put in place. These include overall planning within the political framework begun by the Economic Summit, appropriate participation in the two multilateral agencies involved in fusion, and bilateral agreements with each of the principal fusion program governments.

With these mechanisms there are many different forms of cooperation and collaboration. Information exchange through workshops, visits, assignments, and conferences provides the basis for understanding ongoing work, developing professional working relations, and formulating new ideas for the next research steps. Successful international joint planning builds on this information exchange resulting in an influence on decisions, avoidance of unnecessary duplication and the basis for coordinated activities on complementary facilities or for joint projects on unique facilities.

Near term actions[3] include new discussions and agreements to coordinate concept improvement activity; exchange of personnel on the U.S. and Japanese ignition design teams and discussions on similar possibilities with the EC team; collaboration to supplement major new European experimental facilities with U.S. developed components and expertise; a plan for a broad materials research and development program and discussion of fusion technology needs; increased emphasis on concept innovation in the IAEA INTOR Critical Design Issues Workshop. Furthermore, senior intergovernmental discussions are now proceeding to follow through on the Geneva Summit agreement to "foster the widest practicable international cooperation" in fusion.

Needs for future major facilities are the particular focus of the Technical Working Party (TWP) established within the Economic Summit framework, i.e., the Fusion Working Group. The TWP has recently endorsed the concept of the U.S. proceeding with an ignition and burn experiment as one of the facilities required for fusion. It is expected that over the next two years, specific modes of collaboration in that area will be developed.

While the work of the TWP is not yet complete, it is reasonable to expect that at least one new major facility will be identified as being required in the future for each of the four key technical issues for fusion. For example, the burning plasma facility would resolve the properties of burning plasmas issue and would support an Engineering Test Reactor where nuclear technology issues can be resolved; a Materials Test Facility is needed to resolve the fusion materials development issue. The confinement concept development issue will require one or more major facilities for its resolution. Following the designation of required facilities, joint planning must then be used to specify the design and to agree on the nature of the participation in the common effort.

In 1986, the Office of Fusion Energy (OFE) will develop guidelines for evaluation of existing international activities, for decisions on new collaboration or cooperation, and for determination of approaches to these new activities. These guidelines will be used in the process of considering the findings of the TWP and OFE technical planning. This is part of the increased priority within OFE given to the active management and evaluation of international activities.

FINAL PERSPECTIVES

The evolution of the role of international activities in the U.S. fusion program is evident in the growing emphasis on those problems representing programmatically critical issues, systematic incorporation of international options into the decision process, collaboration where expertise is treated as a commodity and traded for items of comparable value, and managing international activities as an integral part of the program.

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3) Attachment 3 - New U.S. Initiatives in International Fusion Activities

Considering international options can result in more innovative ideas and better, different approaches compared to a purely domestic program. While collaboration on a given project activity generally takes longer than a purely domestic approach, there is a significant opportunity to avoid unnecessary duplication and conserve resources through early joint planning. Management decisions on priorities, balance, and allocation of resources will be more difficult but the additional option can be used as a means for greater flexibility.

Reaching agreements has proven to be a difficult process.[4] The cultural, programmatic, political, legal, and financial obstacles that frequently must be overcome internationally are often invisible in the final document. Further, the confluence of personal, institutional, and programmatic priorities required internationally for success often requires a considerable investment of effort to develop. There are also differences in expectations which sometimes are the result of linguistic and cultural differences. Because of the time, energy, and commitment involved, only the highest priority tasks are being undertaken through the agreement process; those highest priority tasks are ones essential to resolution of one or more of the key technical issues and ones best addressed in a collaboration.

In summary, the use of international activities is consistent with technical, fiscal, and programmatic realities. The potential result of an enhanced level of coordination among the world programs is great.

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4) Attachment 4 - Lessons Learned and Possible Impediments to International Fusion Cooperation and Collaboration

CURRENT U.S. INTERNATIONAL ACTIVITIES IN FUSION

I. Institutional Mechanisms

To implement the strategy, there are several existing mechanisms that are sufficiently flexible to fit a broad range of situations and needs. Initiated through the Economic Summit Process, broad technical discussions are conducted to reach a consensus on the major facility requirements for the further development of fusion, which is a major step toward overall joint planning. The work in fusion has been started by the Economic Summit Working Group in Controlled Thermonuclear Fusion, i.e., the Fusion Working Group (FWG); the Technical Working Party (TWP) was created by the FWG to do the technical analysis needed to form the basis of the FWG positions. The International Energy Agency (IEA) provides the framework for specific large scale collaborative projects involving the U.S., E.C., and Japan. Through bilateral agreements with Japan, U.S.S.R., and soon the E.C., the U.S. is able to focus on areas of broad agreement between each two programs and on the specific tasks of implementation. The International Atomic Energy Agency (IAEA), which includes the U.S.S.R., provides an effective mechanism for information exchange.

These institutional mechanisms have been used to support resolution of each of the four key technical issues as listed below.

U.S. INTERNATIONAL COLLABORATION
IS SUPPORTING RESOLUTION TO KEY ISSUES IN MFPP

KEY ISSUE	INTERNATIONAL ASPECT
Magnetic Confinement Systems	- Summit FWG Sub-Panel on Reactor Concept Improvement Developed General Guidelines for New Facility Steps
Properties of Burning Plasma	- Bilateral Design Exchanges Beginning - TWP Building Consensus on Facility Requirements - FWG Agreed on Ignition Experiment Needed to Support Fusion Nuclear Technology Facility
Materials for Fusion Systems	- IEA Blue Ribbon Panel Developing Program Needs and Priorities, and Optimal Use of Facilities - TWP will Use IEA Report in Developing Recommendations - FWG Agreed a Materials Test Facility is Needed to Complement Fusion Nuclear Technology Facility

Fusion Nuclear Technology	- Ad Hoc Participation by Individual Scientists from the Economic Summit Nations in Technical Planning Study - TWP Reviewing National Programs and Planning Activities - FWG Agreed a Major Facility for Fusion Nuclear Technology (Engineering Test Reactor - ETR) is Common Medium-Term Goal - Geneva Summit Initiative Offers Potential for Enhanced International Collaboration on Such a Major Facility

II. BACKGROUND ON NEW AGREEMENTS

There are several new agreements which have recently been signed or are in the final stages of formalities. This section provides a brief background on these new agreements including an assessment of the future potential for these agreements.

A. IEA

- o Large Tokamaks - This agreement provides the means for information exchange among the three largest magnetic fusion devices in the world, TFTR (US), JET (EC), and JT-60 (Japan). This agreement has the potential to evolve into joint planning and program coordination.

- o ASDEX-Upgrade - This agreement focuses on the use of ASDEX-Upgrade, in Germany, described by the designers as a small version of INTOR. The specific experimental program planned will focus on innovative particle control methods, edge plasma physics, radiofrequency (rf) heating, profile modification with pellets and rf heating, and surface physics studies. ASDEX-Upgrade is a unique facility which can provide resolution of particle control issues which affect core plasma performance. Effective participation by the U.S. in the experimental program saves the U.S. from building a facility to study these issues.

- o Stellarators - This agreement provides for joint planning among complementary programs. A key physics issue for stellarator-type devices is the optimum magnetic field configuration. Through complementary programs, the US, EC, and Japan can each study a well defined region of the configuration spectrum on comparable machines in a coordinated effort and evaluate performance.

B. Bilaterals

- o US-EC - This agreement is in the final stages of formalities. The Bilateral provides the framework for the U.S. to participate in the experimental programs of new machines such as Tore Supra and JET to provide data in key areas such as multimegawatt radio-frequency heating and long pulse physics. The U.S. does not have large programs in these areas.

- o US-People's Republic of China - This agreement is also in the final stages of formalities. Initially, it is expected that there will only be a limited number of selected activities through this channel as both sides explore the best mechanisms for interaction. However, it can be significant in establishing the technical and personal basis for further interaction in the longer term.

- o US-Spain - This agreement provides for specific collaboration in a particular project in stellarator development. Spain is constructing an innovative, unique stellarator with U.S. technical assistance. The advanced approach taken by the Spanish team could have significant future benefits.

III. U.S. PROGRAM NEEDS AND ROLE OF PRESENT AGREEMENTS TO MEET NEEDS

The following Table contains a general list of U.S. fusion program needs with specified areas where international activity does already or could play an important role. The commitment of the U.S. to continue to use international activities and the evolution toward more collaboration is a consistent theme in all the key issue areas.

ROLE OF PRESENT AGREEMENTS IN MEETING U.S. FUSION PROGRAM NEEDS

U.S. Needs	U.S. International Program Activities		
	Current		Potential
Key Technical Issues 1-4	Cooperation/Collaboration		Cooperation/Collaboration
1. Magnetic Confinement Systems - Needs for Improved Technical Base (theory and experiment)			
. conventional tokamak	USSR	EC/Japan	
. tokamak improvements	INTOR		EC/Japan/China
. stellarator	USSR	EC/Spain/ Japan	
. tandem mirror	Japan/USSR		
. reversed field pinch	EC/Japan		EC/Japan
. compact toroids	Japan/USSR		Japan
. other concepts	Japan		
. generic physics, operating modes, and technology (e.g. superconducting magnets and heating and fueling systems)	EC/Japan	EC/Japan Switzerland	EC/Japan (expanded scope)
2. Properties of Burning Plasmas - Needs for basis of technical and design decisions on a device			
. high power ICRH and ECRH systems for high density devices	EC		EC

. confinement physics	Japan/EC/USSR		EC
. theory	Japan/EC/USSR		
. diagnostics			EC/Japan
. high strength copper magnets and the associated materials data base			EC
. high heat flux materials and coatings (pulsed)	EC/Japan		EC/Japan
3. Materials for Fusion Systems - Needs for a coordinated program			
. radiation tolerance		EC/Japan	
. surface tritium effects	EC		EC/Japan
. high heat flux materials and coatings (steady state)		EC/Japan	
. input from IEA Materials Panel on Program needs, priorities, and optimal use of facilities			EC/Japan
4. Nuclear Technology for Fusion Systems Needs for a coordinated program			
. Blanket and Shield	EC/Japan		EC/Japan
. Tritium Technology	EC/Japan		EC/Japan
. Engineering Test Reactor* for resolving nuclear technology issues for fusion			EC/Japan/ USSR

IV. INVENTORY OF U.S. INTERNATIONAL PROGRAM ACTIVITIES

A. TOPICAL AGREEMENTS BY KEY TECHNICAL ISSUE	FORUM	PARTIES
1. Concept Improvement		
Stellarator	IEA	US/EC/Japan**
Advanced Stellarator	US-Spain Commission	US/Spain
Mirror Research, RFC-XX	Bilateral	US/Japan
Joint Planning Committees	Bilateral	US/Japan
. Tandem Mirror		
. Bumpy Torus		
. Compact Torus		
. Heliotron/Stellarator		
. Reversed Field Pinch		

* At the Geneva Summit the U.S. and USSR agreed to advocate the widest practicable development of international collaboration in fusion. Since a nuclear technology facility such as the ETR is a common medium-term goal for all the major fusion programs, such a facility may be the appropriate vehicle to implement the Geneva Summit agreement.

** Provisional participant.

Joint Institute of Fusion Theory	Bilateral	US/Japan
TEXTOR with ALT-I	IEA	US/EC/Japan
ASDEX Upgrade	IEA	US/EC/Japan**
Large Coil Task	IEA	US/EC/Japan/ Switzerland
TEXTOR ALT-II--Pending	IEA	US/EC/Japan
RFP--Under Discussion	IEA	US/EC/Japan

2. Properties of Burning Plasmas

Doublet-III	Bilateral	US/Japan
Large Tokamak Cooperation	IEA	US/EC/Japan
Burning Plasma Studies	Bilateral	US/Japan
Plasma Shaping D-III/JET	Bilateral	US/EC
Joint Planning Committee TFTR/JT-60	Bilateral	US/Japan

3. Materials Development

Neutron Damage	IEA	US/EC/Japan/ Canada
RTNS-II	Bilateral	US/Japan
HFIR/ORR	Bilateral	US/Japan
FNS Neutronics	Bilateral	US/Japan

4. Fusion Nuclear Technology

Small Tritium Handling Components Testing	Bilateral	US/Japan
INTOR Workshop	IAEA	US/EC/Japan/USSR
FINESSE Study	Ad Hoc	Individuals from Summit Nations

B. UMBRELLA BILATERAL AGREEMENTS
US-USSR, US-Japan--Active; US-EC, US-China--Pending Final Formalities; US-Canada--Under Discussion

C. MULTILATERAL ARRANGEMENTS
IAEA, IEA, Economic Summit

** Provisional participant.

COMPLEMENTARITY OF PROGRAM ELEMENTS PURSUED BY US, JAPAN, AND EC

This complementarity is manifested in three different broad ways as shown below in A, B, and C.

A. Serial Development of a Technical Approach in which the Lead Role is taken by Different Programs for Discrete Steps

Examples	Steps
-Tokamak-Based Ignition & Burn:	a. TFTR; D-T Operation, Q=1 b. JET; D-T Operation, Q>1, No Ignition c. US (Proposed): Ignition, No Nuclear Engineering Tests d. EC, Japan (Proposed): Ignition, Some Nuclear Engineering Tests or Engineering Test Reactor arising from Geneva Summit discussions and proposed to involve US, USSR, EC, and Japan
-RFP Concept Development:	a. EC; Confinement with Ohmic Current Up To 2 MA b. US; Confinement with Ohmic Currents Of 2-4 MA
-Heating Technology:	a. EC, Japan: Immediate Needs b. US: Long Range Needs

B. Parallel Development of Different Technical Approaches

1. On Separate, but Comparable Facilities

-Tokamak: EC; Extrapolation of Conventional State-of-the-Art
Japan; Extrapolation of Conventional State-of-the-Art with Inclusion of Some Potential Concept Improvements
US; Compact, High Power Density Design for Ignition Device, Vigorous Support of Other Potential Concept Improvements

-Stellarator: Japan; High Magnetic Shear Configuration
US; Moderate magnetic Shear Configuration
EC; Low Magnetic Shear Configuration

(A Key Technical Issue for Stellarator Development is the Degree to Which Magnetic Shear Should be Incorporated)

-Materials Development: Neutron Irradiation Studies; Complementary Joint US-Japan Use of RTNS-II, HFIR/ORR, and FNS Facilities to Study Different Classes of Alloys, Small Scale Components, and Check Validity of Extrapolation of Low Energy Data

2. Joint Use of a Single, Unique Facility
   -Superconducting Magnet Technology: Large Coil Task using facility in US; Comparison of Different US, Japan, EC, and Swiss Approaches for Conductor and Cryogenic Design
   -Particle Control: TEXTOR (Germany); Joint Development of Pumped Limiters
   -Confinement Physics/Materials Development: ASDEX (Germany); Joint Development of Divertor Physics, High Heat Flux Materials

C. Early Joint Planning

   -Materials Development: IEA Blue Ribbon Panel; Joint Effort to Provide Input on Coordinated Program Design, Needs, and Future Facility Requirements

POSSIBLE NEW INITIATIVES BY KEY TECHNICAL ISSUE

1. Magnetic Confinement Systems

- Needs: Improved Database for Toroidal Systems for Decisions on Concept Development Steps and Concept Evaluation.

a) Initiative Gain long-term access to JET experimental programs. U.S. would provide a pellet injector, not available in Europe, to improve machine performance in the near term and would participate in the planning and execution of experiments on long pulse phenomena and plasma behavior with multimegawatt ICRH, not available in the U.S. This involvement would continue into subsequent experiments particularly for the later phase which is beyond TFTR's capability and which could provide key data for design for the U.S. ignition device. This involvement could be expanded to include other physics and technology areas if mutually desirable and appropriate. An initiative for access to JT-60 in a similar fashion would also be desirable, particularly after more experience is gained in its operation.

Discussion The success of the US pellet injector development program has generated a significant interest in the international fusion community. Initial discussions with JET are under way for providing an injector and executing long-term joint experiments. Of the large tokamaks now operating, JET and JT-60 have aspects of their performance capability which are beyond what will be available in the U.S. in the late 1980's--early 1990's.

b) Initiative Seek a coordinated program to provide for development of the reversed field pinch (RFP) concept with specific, agreed-upon steps for each program and to build upon results and expertise in the design and experimental planning of subsequent machines. This could be an effective means of using fully the skills of the technical people during the various construction periods.

Discussion The US, EC, and Japan have the opportunity to use joint planning to provide shared responsibility for the sequential steps needed to develop the RFP concept further. This responsibility could extend through a number of steps: 1) agreement on sequential device size, 2) physics input from an existing machine to assist the detailed design and physics planning for the next device, and 3) early involvement in conceptual design of one device which will build upon experience elsewhere with present devices.

c) Initiative Utilize selected foreign facilities to continue development of superconducting magnets.

Discussion Since the US ignition device is being planned with copper coils, the near term emphasis on superconducting magnet development will not be as great as before. However, supporting concepts may need superconducting coils. Participation in facilities now planned abroad may be a cost-effective means of continuing this development by making best use of the limited investment in a small number of U.S. coils. Along with coils in a foreign facility from other sources, this investment is highly leveraged. At the same time, the provider of the facility would gain a hands-on systems knowledge comparable to that which the U.S. has already acquired in LCT.

Other Recently Completed Actions of Note:

The emphasis of the INTOR Workshop has been shifted to development of toroidal innovations. This could provide a valuable stimulus for generating innovations and input on their feasibility. The Large Tokamak, ASDEX Upgrade, and the pending Tore Supra Agreements provide for collaboration and cooperation in tokamak development; the IEA Stellarator Agreement provides the framework for complementary development. These new agreements are described briefly in Attachment I. In addition, under IAEA sponsorship, an evaluation of the existing atomic physics data compilation for fusion is being conducted to determine future possibilities for international activities in the data collection and analysis area.

2. Properties of Burning Plasmas

- Needs: An Ignition and Burn Device and the Necessary Applications of Heating Systems, Confinement Physics Database, Copper Magnets and Materials for High Density Systems to Support the Design and Experimental Plan.

a) Initiative Seek foreign participation in the planning and conduct of a U.S. ignition and burn facility.

Discussion The next major step in this key issue is agreement on the scope, timing and cost of the facility required for the experimental study of burning plasmas. The EC and Japan have been involved in technical reviews of U.S. design options and are participating in design studies. While a direct foreign financial stake in the device is certainly desirable, there is a broad spectrum of other possible forms of participation.

b) Initiative Seek to broaden U.S. access to the physics database for high field, high density devices through collaboration with the Frascati Tokamak - Upgrade (FT-U) device in Italy and expanding cooperation with the Soviet Union on such devices.

Discussion The FT and the FT-U device now being built are, along with the MIT Alcator devices, the leaders in the compact, high field genre which includes the designs presently being studied for the U.S. ignition device. Of machines now being constructed, FT-U has parameters and configuration characteristics most similar to those required for the planned ignition device. The Soviet Union also has an interest in compact toroidal designs for fusion programmatic objectives somewhat different from the U.S.; but many aspects of the physics, machine design, and resolution of engineering issues are still pertinent for U.S. purposes.

c) Initiative Investigate the feasibility of collaboration with FT-U on the development of high strength copper magnets and ICRH systems for high density, high field devices. The FT-U data could be helpful in the design and development of ignition machine prototype systems.

Discussion The potential merits of FT-U are discussed in the previous initiative. Other collaborative ICRH programs on ASDEX, ASDEX-Upgrade, Tore Supra, and TEXTOR also have great potential value but such work can be done within existing agreements is deemed appropriate. Each machine has unique features which are pertinent for the ignition/burn device design.

Other Recent Actions of Note:

The Technical Working Party (TWP) has endorsed the U.S. ignition/burn strategy and technical soundness of the design approach. In terms of both the extension from present large tokamaks and the compact design approach, the planned ignition/burn device complements the plans of Europe, Japan, and the consensus position of the Fusion Working Group on an ETR. Exchanges of on-site representatives with Japan for cooperation in the ignition/burn device design studies have begun.

3. Materials for Fusion Systems

- Needs: Materials Development for Radiation Tolerance, Tritium Effects on Surfaces, and High Heat Flux Materials and Coatings (Steady State)

a) Initiative Seek a coordinated materials research and development program based on the findings of the IEA Blue Ribbon Panel.

Discussion After the IEA Materials Panel completes its work, it is clear that intensive discussions on implementation must take place. Substantial collaboration on specific tasks already exists through the IEA and bilateral agreements.

b) Initiative Seek a coordinated program on the effects of tritium on surfaces such as walls, limiters, etc.

Discussion The U.S. has several experimental facilities capable of doing most aspects of this research. The U.S. also has a program for theoretical studies in this area. The tritium laboratories in both Japan and the EC should have some capability of doing experiments and analyses on a similar scale. These efforts could be coordinated into a more complementary research program.

c) Initiative Seek joint ventures on the new UCLA steady state tokamak for plasma-material interaction (PMI) and high heat flux material development issues.

Discussion The UCLA device would be unique for the combination of steady state capability, explicit charter for technology development as an aspect of its scope of work, and the expertise acquired on previous UCLA machines by the same team on PMI and impurity control issues. A joint venture could lead to an enhanced program from which the U.S. and each participant would benefit. The program could be coordinated with the much larger, long pulse Tore Supra device.

Other Recent Actions of Note:

A Blue Ribbon IEA Panel is studying the materials needs for fusion to define the required facilities and to provide initial steps toward joint planning.

4. Nuclear Technology for Fusion Systems

- Needs: Blanket and Shield Concept Development and Evaluation, Tritium Technology Development.

a) Initiative Seek to build upon the FINESSE activity and the TWP work to formulate and implement a coordinated overall plan for developing nuclear technology for fusion systems.

Discussion The FINESSE group has identified key technical issues for the blanket and is preparing recommendations. The next area of focus for the TWP is nuclear technology. An implementation plan is needed to utilize the results of both bodies.

b) Initiative A major facility required to address fusion nuclear technology systems issues. This facility can be called the Engineering Test Reactor (ETR). The Economic Summit's Fusion Working Group has recently reached a consensus "that the joint design, construction and operation of this ETR is a reasonable objective for international collaboration." The U.S. is participating fully as co-leader of the FWG in considering such a major facility as a joint project.

Discussion Extrapolations and modifications of fission nuclear technology are sufficient to satisfy many of fusion's needs. However, fusion does have unique needs owing, for example, to the presence of

relatively high energy (14 MeV) neutron energies where the fission data base is either unreliable or non-existent. For the required fluences and lifetimes expected for an economically viable fusion reactor, facilities from non-fusion programs are not adequate. The ETR would be the blanket testing facility to fill this need. Active and substantial participation by the world's major fusion programs is being sought.

c) Initiative At the Geneva Summit, the U.S. and USSR agreed to advocate the widest practicable development of international cooperation in fusion. It is generally agreed by the Economic Summit Working Group on Controlled Thermonuclear Fusion that a major facility to resolve fusion's nuclear technology issues is a common medium-term goal for all fusion programs. Consequently, proceeding with such a major fusion nuclear technology facility as a joint four-party effort might have the potential of being an appropriate direction for implementation of the Geneva Summit initiative.

Discussion Collaboration on a joint, four-party project to design, build and operate such a major facility would have the advantages of strengthening the technical team and reducing budgetary costs compared to proceeding with fewer participants. Disadvantages include the added complexity of managing a four-party project in a cost-effective manner consistent with existing technology transfer policies.

d) Initiative Seek access to the new tritium laboratories being built in Japan and the EC and work toward coordinated planning similar to FINESSE in the development of tritium technology. The expertise and facilities at TSTA, which is both now and probably well into the 1990's the premier fusion tritium technology development laboratory in the world, can be used to provide input for the design and experimental programs planned for the new laboratories.

Discussion Japan is building and Europe is planning to build tritium facilities to support the development of the necessary technology to breed, process, control and handle tritium safely and efficiently in a fusion environment. Both could benefit significantly from US expertise developed primarily at TSTA in their facility design, programs, and licensing procedures. In return, the US could obtain access to experiments of interest and have input into their programs.

Other Recent Actions of Note:

Collaboration on blanket concepts could evolve naturally from the FINESSE study in which individual scientists from the Economic Summit nations participate. The US, EC and Japan are studying different concepts; a coordinated approach to these concepts would be desirable.

LESSONS LEARNED AND POSSIBLE IMPEDIMENTS
TO INTERNATIONAL COLLABORATION*

Lessons Learned

Thirty years of experience in international collaboration have led the U.S. fusion program to appreciate fully the difficulty involved in reaching and implementing agreements, even among political allies.

Among the important lessons learned in fusion from previous collaborations are that:

- o time spent to understand foreign institutional relationships and cultural nuances is well spent,
- o confidence in the integrity and capability of the partners on both the political and technical level is required by all sides,
- o careful planning, preparation, and domestic coordination are essential,
- o early consultation to identify mutual needs and to develop the best ideas is crucial,
- o agreements must clearly define roles and responsibilities and goals, and
- o firm commitments must be honored.

Possible Impediments to International Collaboration

Recommendations were made to the Economic Summit leaders at their recent Bonn meeting by an Administrative Working Group on changes needed to lessen administrative barriers to international cooperation. The Working Group included U.S. representatives in high energy physics and fusion. Specific recommendations by the Group included: revision of tax and tariff provisions to lengthen the time exemption to ten years or more on contributions of scientific equipment and components from one nation to another; facilitating the exchange of scientific staff by simplifying the administrative admission formalities in the host country, and by direct support for the social integration of the researcher and family; reviewing the changing policies for transmitting scientific data across borders; and

*Excerpted from Dr. John Clarke's testimony to Congressman D. Fuqua's Science Policy Task Force, June 1985

promoting effective data communication standards for compatibility. Technology transfer and export controls can also create difficulties in international cooperation particularly with nations such as the U.S.S.R. We are participating in the effort to have a clear definition for basic scientific research which would be exempted from the technical information provisions of the Export Administration Act.

Another important management concern is that the technical issues now involved in major collaboration require multi-year programs. Multi-year funding would assure continuity for the tasks and increase the potential effectiveness of the effort. Multi-year funding would clearly demonstrate the commitment of the comprehensive support of the Administration and Congress. This point is important since the EC operates on a multi-year budget cycle and the Japanese, while using an annual budget process, do operate on a multi-year planning cycle and can make firm long-term commitments. This ability to make commitments provides us with confidence in their intentions; if we could reciprocate, our counterparts would have similar assurances. Another possible concern which is manageable now is the commercial potential of the technology developed for fusion. This is a unique aspect of our program. While fusion as an energy source is a long range commercial option, some of the technology components have near-term applications outside fusion.

• U.S. GOVERNMENT PRINTING OFFICE: 1996-491-177:30177

QUESTIONS FROM SENATOR MALCOLM WALLOP

Question 268. Give details on the plans for cooperation with the Soviet Union in a Tokamak research facility, which the Committee has heard will be placed in Geneva, Switzerland.

Answer: No plans have been made for cooperation with the Soviets on a tokamak research facility in Geneva. Prior to the Geneva Summit, the Soviets raised the possibility of agreeing to the building of an Engineering Test Reactor. At the Summit, the United States argued strongly that it was premature to agree to such a project. We argued that more study was necessary on the feasibility of such a project. In addition, cost-sharing details would have to be thoroughly studied and participation would have to be sought from other technically advanced countries. Most importantly, we stressed that any such project would have to be within the guidelines of COCOM, and that we could not participate in a project that would have significant military benefits to the Soviet Union. However, the United States and Soviet sides did agree that further fusion collaboration of some sort could be beneficial, and the communique expresses ". . . the importance of the work aimed at utilizing controlled thermonuclear fusion for peaceful purposes, and in this connection, advocated the widest practicable development of international cooperation in obtaining this source of energy, which is essentially inexhaustible, for the benefit of mankind".

In response to the joint Reagan/Gorbachev communique from the Geneva Summit and the President's wishes, we in the Executive Branch have been proceeding in a cautious and deliberate manner to examine possible modes of cooperating with the Soviets in a more significant way. We are examining the issues in a special National Security Council Working Group formed for this purpose.

The Group has been reviewing the issues of technology transfer, budgetary implications, fusion as a science priority, and international foreign policy implications.

There has been one meeting with the Soviets since the Geneva Summit. This meeting was held in early April to further discuss fusion cooperation. A U.S. team, led by Dr. Alvin W. Trivelpiece, Director of the Department's Office of Energy Research, and including representatives from the National Security Council staff, Department of Defense, the Office of Science and Technology Policy, and the Department of State, met with a Soviet team in Geneva. The U.S. team went to listen to the Soviets' ideas on fusion cooperation. The Soviets were enthusiastic about collaboration on something like an Engineering Test Reactor. They suggested that such a device could be built on the Czechoslovakia-West German border. The U.S. argued that there were several key items that must be considered before one could consider collaborating on an Engineering Test Reactor.

We are presently analyzing these items. We are using the extensive and well documented International Atomic Energy Agency study of the International Tokamak Reactor (INTOR) as a concrete basis for our analysis.

The meeting with the Soviets was characterized by a businesslike atmosphere with each side making basically its own arguments. The only agreement was that further discussion on this matter was needed. The next meeting has not been set.

QUESTIONS FROM SENATOR MALCOLM WALLOP

Question 26C. Please explain why DOE plans to cooperate in that project, when our own laser-based technology may well prove to be the better method for nuclear fusion energy development.

Answer: As noted in Answer 7.B. above, no decision has been made to cooperate with the Soviets on an Engineering Test Reactor. We are presently analyzing the issues affecting such a decision. However, the tokamak is the most technically advanced approach to fusion, and the unanimous choice of the world's fusion programs, as the most promising approach to fusion energy development. Therefore, we believe that from a technical point of view, the Tokamak Fusion Program is the appropriate focus of cooperation with the Soviets, if such a decision were to be made.

QUESTIONS FROM SENATOR MALCOLM WALLOP

Question 260. Please detail plans for preventing Soviet access to sensitive computer technology in a joint U.S./USSR or Japan/EEC/USSR fusion energy research facility.

Answer: Detailed mechanisms to prevent the undesirable transfer of any technology during a cooperative project would have to be negotiated with the potential partners. At this point, we have only examined potential risks and the potential means for controlling those risks. At this time, we see no real problems with preventing access to this technology in general. Under all circumstances, any agreement that would be made would follow existing COCOM rules and procedures.

Department of Energy
Washington, DC 20585

June 13, 1986

Honorable Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On April 29, 1986, James W. Vaughan, Jr. Acting Assistant Secretary for Nuclear Energy, appeared before the Energy and Natural Resources Subcommittee on Energy Research and Development to discuss the FY 1987 budget authorization for civilian radioactive waste management.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Mike Gilmore or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

ADDITIONAL POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

APRIL 29, 1986 HEARING

BEFORE THE

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

WITNESS: JAMES W. VAUGHAN, JR.

ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY

U.S. DEPARTMENT OF ENERGY

QUESTIONS FROM SENATOR DALE BUMPERS

Question 1: Please provide a list (which includes a brief description and the FY 87 funding request) of the Department's nuclear research activities which have space and military applications. Provide a second list of those programs which also have civilian applications. Briefly describe the civilian application.

Answer: The program is conducted within four activities: Advanced Reactor Research and Development (R&D), Space and Defense Power Systems, Advanced Nuclear Systems, and Facilities.

The Advanced Reactor R&D budget ($49.5 million) is directed primarily towards civilian efforts. The Space and Defense Power Systems ($71.65 million) and Advanced Nuclear Systems ($23.6 million) are directed towards defense and civilian efforts for NASA space applications. It is expected that portions of the civilian and defense efforts would be mutually beneficial to both activities. The Department's nuclear-related research and test facilities ($121.8 million) are currently managed as integrated units, and the present costing practices do not provide for the allocation of costs between civilian and military activities. Incremental costs of specific tests and experiments conducted for the various activities are funded by the activity requiring the test from within the funds indicated above.

Answer 1
(continued): Nuclear research activities that have space and defense applications, along with the FY 1987 budget request and a brief description of planned FY 1987 and outyear activities, follows.

1. SP-100 GROUND ENGINEERING SYSTEM ($30.0 million):

FY 1987 Key Milestones:

- o Complete the design for the ground engineering system (GES) reactor test site (facility modifications and required systems) (1/87)
- o Complete pre-modification removal and relocation of major equipment at the test site (4/87)
- o Complete reference flight system design at the component level (8/87)
- o Complete NEPA documentation for the test site (9/87)
- o Continue technology development on reactor fuel and the energy conversion subsystem through the year.

Outyear Key Milestones:

- o Freeze GES reactor and energy conversion design (8/88)
- o Initiate GES subsystem testing (1st quarter FY 1990)
- o Initiate GES reactor performance test (3rd quarter FY 1990)
- o Reactor and energy conversion subsystems validated. (8/91)

Answer 1 (continued):

2. DYNAMIC ISOTOPE POWER SYSTEMS (DIPS) ($13.0 million):

FY 1987 Key Milestones:

- o Start conceptual design for DIPS with both Brayton and organic Rankine conversion cycles (12/86)
- o Conduct safety and survivability analyses for the DIPS/conceptual design (4/87)
- o Initiate key component development and life testing (8/87)

Outyear Key Milestones:

- o Complete component development and initiate fabrication of engineering unit with selected conversion cycles (9/90)
- o Complete engineering unit fabrication and initiate testing (9/91)

3. SMALL NUCLEAR POWER SOURCE DEMONSTRATION PROJECT ($2.0 million):

FY 1987 Key Milestones:

- o Complete core mockup nuclear testing
- o Initiate power conversion system testing
- o Complete fabrication and assembly of demonstration unit reactor
- o Initiate fuel loading

Outyear Key Milestones (reimbursable funding):

- o Initiate and complete reactor zero power testing.
- o Transfer reactor to the Whiteshell Nuclear Research Establishment (WNRE) and initiate system testing.
- o Complete acceptance testing.

Answer 1
(continued):

4. MULTIMEGAWATT (MMW) REACTOR SYSTEMS ($23.7 million):

FY 1987 Key Milestones:

- o Issue preliminary surety guidelines (3/87)
- o Develop concept selection criteria and concept evaluation methodology (4/87)
- o Demonstrate fabricability of advanced fuels and materials (7/87)

Outyear Key Milestones:

- o Complete in-space testing to resolve key technical issues (5/90)
- o Complete reactor testing of fuels and materials and thermionic fuel element (3/91)
- o Downselect to at least one nuclear concept (6/91)

5. MULTIMEGAWATT TERRESTRIAL POWERPLANT ($3.0 million):

FY 1987 Key Milestones:

- o Award contract (late FY 1986 or early FY 1987)
- o Complete topographical and site surveys; preliminary safety analysis report; preliminary availability analysis; and, piping and instrumentation drawing and plot/building plans (8/87)

Outyear Key Milestones:

- o Complete detailed design (6/89)
- o Start construction (9/89)
- o Complete construction (1/92)

Answer 1 (continued): Requirements of advanced civilian nuclear reactor powerplants include improved economics through modularization, standardization, factory fabrication, high availability and reliability; ease of operation and maintenance; long life core components; passive safety; advanced control systems and logistics; and waste heat and effluent management. These requirements apply equally to large, land-based nuclear power sources for defense applications.

Commonality between the civilian and defense programs can be seen from the perspective of the research and development infrastructure involved in responding to these common requirements and the importance of maintaining a cadre of qualified scientists and engineers. The utilization of personnel and facilities, the similar underlying bases for fuel and material testing, and analysis of concepts will provide benefits to the civilian program.

These principal benefits will be available for the development of advanced civilian powerplants and will relieve much of the uncertainty associated with the introduction of the new technologies. In addition, the space reactor efforts will require the development of new materials, fuel forms or other advanced technology that, history has shown, are likely to find application in the civilian sector.

Answer 1 (continued): The space and military programs that also have civilian applications involve liquid metal systems, fuels and materials, and control systems. Some possible examples are:

- o One hundred to 1,300 megawatt electric (MWe) systems, developed for powering ground-based SDI systems. The duty cycle required by these SDI systems places a premium on transient response and capability to rapidly power up for durations of a few minutes or longer.

- o 10 MWe reactors planned for military bases that could be adapted to industrial cogeneration or to remote locations where fuel supply logistics and total life cycle costs dominate the selection process.

- o Applications dictating high temperature fuel, coolant, materials technology, compact shielding, and remote instrumentation and control.

QUESTIONS FROM SENATOR DALE BUMPERS

Question 2: The development of a second generation of nuclear plant designs -- simplified licensable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?

Answer: Yes, the Administration's policies and programs are centered on encouraging the development of simplified and more reliable designs which provide improved safety systems. Over 30 years of development and operating experience are being applied in an effort to introduce advanced light water reactors in the 1990's and beyond. Our work on advanced concepts will continue even if licensing reform legislation is not enacted during this session of the 99th Congress. However, the utilization of these advanced designs may never occur unless legislation is enacted that provides the incentive for the industry and the public to resolve safety concerns before new projects are begun.

QUESTIONS FROM SENATOR DALE BUMPERS

Question 3: The approval of standardized designs is the linchpin of the Administration's nuclear licensing reform bill. Under the level of funding contemplated by the Administration's budget request for advanced light water reactor research, your testimony states that DOE expects to achieve NRC certification of at least two ALWR systems in approximately 5 years. What is the timetable for NRC certification of the liquid metal reactor and high temperature gas-cooled reactors? Are these timetables and funding levels consistent with the Administration's commitment to licensing reform legislation? Wouldn't we be putting the cart before the horse by pushing reform legislation now?

Answer: No, we are not "putting the cart before the horse" by advocating nuclear licensing reform at the present time, even though certification for Advanced Light Water Reactor (ALWR), High Temperature Gas Reactor (HTGR), and Liquid Metal Reactor (LMR) designs are several years away.

Licensing reform is not keyed to the development of advanced reactors. The NRC could approve as standardized designs currently operating designs or modifications of those operating designs, as well as designs for advanced reactors when they reach sufficient maturity.

Licensing reform is needed now and has been for some time.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

June 19, 1986

The Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research
and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed are Commission responses to questions received in your April 30, 1986 letter regarding the April 29, 1986 hearing before your subcommittee on Budget Oversight of DOE's FY 87 Nuclear Activities.

If we can be of further assistance, please contact us.

Sincerely,

Edward Jay

Carlton Kammerer, Director
Office of Congressional Affairs

Enclosure:
As stated

QUESTION 1. CAN YOU GIVE US SOME EXAMPLES OF WHERE THE NRC SAFETY RESEARCH HAS PAID OFF IN TERMS OF IMPROVED SAFETY AND REDUCED COSTS AT OPERATING NUCLEAR POWER PLANTS?

ANSWER.

THE NRC SAFETY RESEARCH PROGRAM IS NOT AIMED AT REDUCING COSTS AT OPERATING NUCLEAR POWER PLANTS, RATHER THE ORIENTATION OF THE PROGRAM IS TO ASSURE A CORRECT AND FULL UNDERSTANDING OF SAFETY PROBLEMS, AND TO PROVIDE TECHNICALLY SOUND METHODS OF REGULATORY ASSESSMENT AND REGULATION.

THE NRC HAS VERY EFFECTIVELY UTILIZED RESEARCH RESULTS TO EITHER PROMULGATE NEW REGULATIONS OR MODIFY EXISTING REGULATIONS WHEN NECESSARY. INSTANCES WHERE RESEARCH RESULTED IN REDUCED OR MORE STRINGENT REGULATIONS ARE PROVIDED BELOW. IN THOSE AREAS WHERE THE NRC WAS ABLE TO REDUCE STRINGENCY, THERE WAS A CORRESPONDING REDUCTION IN COST TO THE PUBLIC.

QUESTION 1. (CONTINUED) -2-

- A FUNDAMENTAL OVERHAUL OF 10 CFR 20 WAS ISSUED AS A PROPOSED RULE. THIS UPDATE WILL IMPOSE MORE STRINGENT REQUIREMENTS FOR RADIATION PROTECTION IN SOME AREAS, SUCH AS: (A) FOR CERTAIN RADIONUCLIDES, THE INTAKE LIMITS ARE BEING LOWERED; (B) THE MAXIMUM WHOLE BODY DOSE IS REDUCED FROM 12 REMS TO 5 REMS; (C) PART 20 WILL ESTABLISH, FOR THE FIRST TIME, A LIMIT OF .5 REMS FOR THE EMBRYO/FETUS; AND (D) THE DOSE LIMIT FOR THE EXTREMITIES WILL BE REDUCED FROM 75 REMS DOWN TO 50 REMS.

- THERMAL HYDRAULIC SAFETY ANALYSES, AS PART OF ANTICIPATED TRANSIENTS WITHOUT SCRAM (ATWS) RESEARCH, REVEALED THAT OVERPRESSURE TRANSIENTS IN BOILING WATER REACTORS CAN RESULT IN COLLAPSE OF VOIDS IN THE CORE WITH AN ACCOMPANYING RAPID INCREASE IN REACTIVITY. LICENSEES WERE REQUIRED TO INSTALL AUTOMATIC PUMP TRIPS UPON OVERPRESSURE FOR ALL BWRS.

- MULTIFUEL-ROD BURST RESEARCH REVEALED THAT LICENSEE ANALYTICAL MODELS USED TO DETERMINE CONFORMANCE TO NRC'S EMERGENCY CORE COOLING REGULATORY REQUIREMENTS (APPENDIX K) WERE INCORRECT IN THREE AREAS: (A) RUPTURED RODS REDUCE FLOW

AREA, (B) STRAINED CLAD HAS ENLARGED AREA FOR OXIDATION, AND (C) TIME OF RUPTURE WAS MISUNDERSTOOD. VENDORS HAD TO REVISE THEIR MODELS RESULTING IN SOME FUEL OPERATING LIMIT STRINGENCIES.

- A NEW RULE, 10 CFR §50.61, "FRACTURE TOUGHNESS REQUIREMENTS FOR PROTECTION AGAINST PRESSURIZED THERMAL SHOCK EVENTS," WAS PUBLISHED IN JULY 1985. THE RULE INCORPORATES A "SCREENING CRITERION" THAT EFFECTIVELY LIMITS THE EMBRITTLEMENT PERMISSIBLE BY THE END OF PLANT LIFE. IF EXCEEDED, ADDITIONAL ANALYSIS AND IMPLEMENTATION ARE REQUIRED FOR CONTINUED OPERATION BEYOND THE SCREENING CRITERION LIMIT. THE RES PROGRAM PROVIDED ALL THE METALLURGICAL AND IRRADIATION EFFECTS DATA, PLUS THE ANALYTICAL PREDICTION METHODS NEEDED TO DEVELOP THE RULE AND TO FORMULATE THE SPECIFIC VALUES IN THE SCREENING CRITERION.

- EXEMPTIONS TO GENERAL DESIGN CRITERIA 4 FOR SEVERAL NEAR-TERM OPERATING LICENSES (NTOLS) TO REMOVE SPECIFIC PIPE WHIP RESTRAINTS AND JET IMPINGEMENT BARRIERS, WITH ATTENDANT SAFETY BENEFITS, WERE BASED, IN PART, ON PROBABILISTIC STUDIES ON PIPE RUPTURE PERFORMED BY LAWRENCE LIVERMORE NATIONAL LABORATORY. FOLLOWING THIS, A LIMITED SCOPE

RULEMAKING WAS INITIATED, AND IS ESSENTIALLY COMPLETE, TO PERMIT SUCH REMOVAL WITHIN THE REGULATIONS.

- o DAMPING VALUES FOR PIPING SPECIFIED IN R.G. 1.61 WERE MODIFIED BY ASME CODE CASE N-411 BASED UPON EXPERIMENTAL DATA DEVELOPED BY INEL. THIS MODIFICATION PERMITS MORE FLEXIBLE AND THUS MORE RELIABLE PIPING WITH FEWER SEISMIC SNUBBERS.

- o RECOMMENDATIONS BY THE PIPING REVIEW COMMITTEE TO THE EXECUTIVE DIRECTOR FOR OPERATIONS WERE MADE FOR MODIFYING SRP 3.9.2, AND R.G. 1.92, TO INCORPORATE THE INDEPENDENT SUPPORT MOTION METHOD FOR PIPING, WHICH PROVIDES MORE ACCURATE ESTIMATIONS OF PIPING BEHAVIOR, BASED UPON ANALYTICAL STUDIES PERFORMED BY BROOKHAVEN NATIONAL LABORATORY. ACCEPTANCE OF THIS RECOMMENDATION HAS ASSISTED IMPLEMENTATION OF THE NRC NONMANDATORY SNUBBER REDUCTION PROGRAM.

- o COMPLETED RES ANALYSIS OF ONSITE/OFFSITE ELECTRICAL SYSTEMS RELIABILITY IS NOW BEING USED BY STAFF IN FORMULATING THE RESOLUTION OF UNRESOLVED SAFETY ISSUE A-44, STATION BLACKOUT (REVISION TO 10 CFR 50, APPENDIX A, CRITERIA 17 AND 18).

- o RESULTS OF COMPLETED RESEARCH AND CONTRACTOR SUPPORT EFFORTS NOW BEING USED BY THE STAFF TO CONCLUDE WORK ON THE FOLLOWING ADDITIONAL SAFETY ISSUES: (1) B-56, "RELIABILITY

REQUIREMENTS FOR DIESEL GENERATORS," AND (2) B-61, "ALLOWABLE OUTAGE TIMES FOR EMERGENCY CORE COOLING SYSTEMS."

- TWO REVISIONS OF 10 CFR 50.44 REQUIRING HYDROGEN CONTROL FOR TWO CLASSES OF LWRS WERE ISSUED BASED ON RES ASSESSMENTS OF THE POTENTIAL CONSEQUENCES OF HYDROGEN IGNITION DURING POSTULATED SEVERE REACTOR INCIDENTS. THE NRC RESEARCH EXPERIMENTS ON HYDROGEN IGNITION AND BURN ENVIRONMENT IDENTIFIED THE POTENTIAL FOR SIGNIFICANT TEMPERATURES WHICH COULD THREATEN EQUIPMENT SURVIVAL IN SMALL CONTAINMENTS SUCH AS THE ICE CONDENSER PWR AND BWR MARK III. THIS RESULTED IN THE INCLUSION OF THIS CONSIDERATION IN 10 CFR 50.44. ALSO, SUBSEQUENT EXPERIMENTS ESTABLISHED THAT LOCATING IGNITORS IN CONTAINMENT WOULD PROVIDE A COST EFFECTIVE WAY OF LIMITING THE HYDROGEN BUILDUP IN CONTAINMENT FROM AN ACCIDENT AND ASSURE EQUIPMENT SURVIVAL. AS A RESULT NRC REQUIRED THAT LICENSEES INSTALL A HYDROGEN GAS CONTROL SYSTEM.

- NRC RESEARCH SUPPORTED THE DEVELOPMENT OF TECHNICAL CRITERIA FOR 10 CFR PART 60, ON DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGICAL REPOSITORIES. APPROPRIATE REQUIREMENTS WERE ESTABLISHED FOR WASTE CONTAINMENT, CONTROL OF RELEASE AND MULTIPLE BARRIER DESIGNS.

QUESTION 1. (CONTINUED) -6-

- RESEARCH IN NONDESTRUCTIVE EXAMINATION (NDE) FOR STAINLESS STEEL PIPING PROVIDED THE TECHNICAL BASIS FOR ISSUANCE OF BULLETIN 83-02 WHICH DEALS WITH PERFORMANCE DEMONSTRATION REQUIREMENTS TO QUALIFY INSPECTORS AND THEIR EQUIPMENT FOR IN-SERVICE INSPECTION OF BWR STAINLESS STEEL PIPING.

- 10 CFR 50.49, WHICH DEALS WITH ENVIRONMENTAL QUALIFICATION OF ELECTRICAL EQUIPMENT IMPORTANT TO SAFETY CONTAINS MORE STRINGENT REQUIREMENTS FOR CONSIDERATION OF RADIATION DOSE RATE EFFECTS AND SYNERGISTIC EFFECTS. THESE REQUIREMENTS FLOW DIRECTLY FROM NRC-SPONSORED RESEARCH ON QUALIFICATION TESTING PROCEDURES.

- NRC RESEARCH ON IN-SERVICE INSPECTION (ISI) HAS RESULTED IN MORE STRINGENT INSPECTION REQUIREMENTS THROUGH MODIFICATION OF THE ASME BOILER AND PRESSURE VESSEL CODE.

- STEAM GENERATOR RESEARCH THAT WILL BE COMPLETED IN LATE 1986 IS EXPECTED TO PROVIDE THE BASIS FOR MORE STRINGENT INSPECTION AND TUBE PLUGGING CRITERIA WHICH WILL BE IMPLEMENTED IN REVISIONS TO REGULATORY GUIDES 1.83 AND 1.121.

- APPENDIX R TO 10 CFR PART 50 SPECIFIED FIRE PROTECTION REQUIREMENTS FOR EXISTING LWR PLANTS THAT, IN SOME CASES,

WENT BEYOND THEN CURRENT PRACTICE INCLUDING REQUIREMENTS FOR SEPARATION OF CABLES AND EQUIPMENT OF REDUNDANT TRAINS BY HORIZONTAL DISTANCE OF MORE THAN 20 FT. ADDITIONAL CABLE FIRE SCREENING CRITERIA WERE IMPOSED BY REG. GUIDE 1.131 ON QUALIFICATION TESTS OF ELECTRIC CABLES FOR LWR REACTORS.

- PIPING RESEARCH PROGRAMS HAVE RESULTED IN MORE STRINGENT REQUIREMENTS FOR ACCEPTANCE OF FLAWS IN STAINLESS STEEL PIPES. THIS HAS BEEN IMPLEMENTED BY INCLUSION IN THE ASME CODE (SECTION XI, IWB-3640) AND WILL BE INCORPORATED BY ENDORSEMENT IN 10 CFR 50.55(A).

- REG. GUIDE 1.97, DEALING WITH INSTRUMENTATION NEEDED DURING AND FOLLOWING AN ACCIDENT, IDENTIFIED THE NEED FOR SUCH INSTRUMENTATION TO BE QUALIFIED FOR CONDITIONS THAT MIGHT BE ENCOUNTERED IN SEVERE ACCIDENTS.

- RES RESEARCH DEVELOPED A SPECIAL COMPUTER CODE (FRANTIC) FOR THE EVALUATION OF PLANT TECHNICAL SPECIFICATIONS. THIS CODE IS USED ROUTINELY BY BOTH INDUSTRY AND THE NRC LICENSING STAFF IN DEALING WITH MODIFICATIONS TO PLANT TECHNICAL SPECIFICATIONS, WITHOUT THE ISSUANCE OF FORMAL REGULATORY GUIDES.

QUESTION 1. (CONTINUED) -8-

- RES-SPONSORED PRA STUDIES HAVE IDENTIFIED A NUMBER OF IMPORTANT VULNERABILITIES IN CERTAIN OPERATING REACTORS. FOR EXAMPLE, THE ADDITION OF AN AUXILIARY FEEDWATER TRAIN TO THE CALVERT CLIFFS PLANT AND MODIFICATIONS TO LOAD-SHEDDING SWITCHES AT MILLSTONE (A SINGLE-FAILURE EVENT WHICH COULD HAVE DISABLED THE EMERGENCY CORE COOLING SYSTEM AT THAT PLANT).

- IN ALMOST EVERY PRA SPONSORED BY RES, THERE HAS BEEN SOME FOLLOW-UP MODIFICATION MADE BY THE AFFECTED UTILITY, GENERALLY ON ITS OWN INITIATIVE, EITHER TO THE ENGINEERED PLANT SAFETY SYSTEMS OR TO PLANT OPERATING PROCEDURES IN ORDER TO PROVIDE A MORE RELIABLE SAFETY SYSTEM.

- THROUGH AN NRC-FUNDED EFFORT, AN ACCREDITATION PROGRAM WAS ESTABLISHED AT THE NATIONAL BUREAU OF STANDARDS FOR PERSONNEL DOSIMETRY PROCESSORS. RESEARCH REVEALED WIDESPREAD POOR PERFORMANCE AND LED TO THE DEVELOPMENT OF A PROVEN PERFORMANCE STANDARD. THROUGH THIS PROGRAM, PROCESSOR PERFORMANCE HAS DRAMATICALLY IMPROVED; THE TEST FAILURE RATE WAS REDUCED FROM 52 PERCENT TO 7 PERCENT.

- NRC RESEARCH FUNDS WERE USED TO DETERMINE REGULATORY CONSTRAINTS WHICH ARE APPLIED IN THE DESIGN, TESTING AND USE OF RESPIRATORY PROTECTION EQUIPMENT FOR AIRBORNE RADIOIODINES.

QUESTION 2. COULD YOU DISCUSS SOME OF THE RESEARCH AREAS IN WHICH DOE AND NRC PLAY COMPLEMENTARY ROLES?

ANSWER.

THE NRC MAINTAINS CLOSE COMMUNICATION WITH THE DOE TO ASSURE THAT OUR PROGRAMS ARE COMPLEMENTARY AND NOT UNNECESSARILY DUPLICATIVE. THIS COMMUNICATION OCCURS IN THE FORM OF COORDINATING MEETINGS AND EXCHANGE OF PROGRAM INFORMATION ON AREAS OF JOINT INTEREST. SPECIFICALLY, THERE IS A DOE-NRC COORDINATING COMMITTEE THAT MEETS REGULARLY DURING THE YEAR AND RESEARCH TOPICS ARE AMONG THOSE DISCUSSED AT THE MEETINGS. EVERY YEAR NRC CONDUCTS A WATER REACTOR SAFETY RESEARCH INFORMATION MEETING IN WHICH ALL NRC AND SOME DOE RESEARCH RESULTS ARE PRESENTED. THE NRC ANNUALLY DEVELOPS AND DISSEMINATES A LONG RANGE RESEARCH PLAN TO EXPRESS WHAT RESEARCH IS BEING UNDERTAKEN AND HOW IT IS TO BE USED.

A SIGNIFICANT PORTION OF THE NRC'S RESEARCH BUDGET IS SPENT AT DOE NATIONAL LABS. THIS RESULTS IN SIGNIFICANT TRANSFER OF TECHNOLOGY FROM DOE TO NRC AND BACK. THE TEST FACILITIES THAT DOE MAINTAINS AT THE NATIONAL LABS ARE AN IMPORTANT RESOURCE TO BOTH THE NRC AND DOE. BOTH AGENCIES ARE WORKING ON LIGHT WATER REACTOR SAFETY RESEARCH AND ADVANCED REACTOR SAFETY CONCEPTS.

QUESTION 3. ARE THERE SPECIFIC AREAS OF RESEARCH RELEVANT TO NRC REGULATORY NEEDS IN WHICH DOE COULD PLAY A STRONGER ROLE?

ANSWER.

RESEARCH TO IMPROVE THE RELIABILITY OF CURRENTLY OPERATING PLANTS IS BADLY NEEDED IN THE LIGHT OF RECENT STATISTICS SHOWING THAT, ON THE AVERAGE, U.S. NUCLEAR POWER PLANT CAPACITY FACTORS ARE FAR BELOW THOSE OF MAJOR INDUSTRIAL NATIONS SUCH AS JAPAN AND THE FEDERAL REPUBLIC OF GERMANY. THESE NATIONS USE REACTORS SIMILAR TO THOSE USED IN THE U.S., BUT PLANT CAPACITY FACTORS ARE ANYWHERE FROM 15 TO 30 PERCENT HIGHER, ON THE AVERAGE, THAN IN THE U.S. THE NRC STRONGLY BELIEVES THAT A PLANT WHICH OPERATES WELL, WITH A MINIMUM NUMBER OF DEMANDS ON ITS SAFETY SYSTEMS, IS A SAFER PLANT. RESEARCH TO BRING ABOUT THIS IMPROVED PERFORMANCE, WITH ITS OBVIOUS ECONOMIC BENEFIT, IS PROPERLY WITHIN THE SCOPE OF DOE.

ANOTHER KEY AREA OF RESEARCH IS ON THE BASIC MECHANISMS OF IN-SERVICE DEGRADATION OF MATERIALS (INCLUDING WATER CHEMISTRY) AND KEY COMPONENTS, AND TECHNIQUES OF IN-SERVICE AND NONDESTRUCTIVE EXAMINATION TO MONITOR SUCH DEGRADATION. PARTICULAR EMPHASIS SHOULD BE PLACED ON THE PRIMARY COOLANT SYSTEM BOUNDARY. THE DOE ROLE COULD BE TO PROVIDE BASE-LEVEL RESEARCH FACILITIES (E.G., TEST LOOPS) TO ACCOMPLISH THIS WORK. SUCH WORK, WHICH WOULD BE

USEFUL IN ENHANCING ON-LINE AVAILABILITY, WOULD ALSO COMPLEMENT THE NRC SAFETY-RELATED RESEARCH IN THIS AREA. OPPORTUNITIES FOR COOPERATIVE RESEARCH WOULD BE SOUGHT, AND WELCOMED.

CLOSELY RELATED IS WORK DIRECTED AT PLANT LIFE EXTENSION, SUCH AS DEVELOPMENT OF IN-SITU PRESSURE VESSEL ANNEALING OR OTHER RENOVATION TECHNIQUES, AND STUDY OF THE BASIC MECHANISMS OF ENVIRONMENTAL DAMAGE TO INSTRUMENTS AND KEY COMPONENTS. THE NRC ALREADY HAS SOME SAFETY-RELATED WORK IN THIS AREA. IF THE DOE WOULD DEVELOP RELIABILITY-RELATED RESEARCH PROGRAMS, THERE COULD BE SOME OPPORTUNITIES FOR COOPERATION WITH NRC.

COMMISSIONER ASSELSTINE ADDS THE FOLLOWING:

MANY OTHER COUNTRIES HAVE AND ARE TAKING U.S.-DEVELOPED TECHNOLOGY AND MINIMUM SAFETY STANDARDS, AND BUILDING ON THEM TO HAVE BETTER NUCLEAR PLANTS WITH GREATER DEFENSE-IN-DEPTH THAN THAT BEING ACHIEVED IN THIS COUNTRY. THESE OTHER COUNTRIES HAVE BETTER DESIGNED PLANTS THAT ARE OPERATED AND MAINTAINED BETTER THAN THE U.S. PLANTS AND THAT ARE SAFER THAN THE U.S. PLANTS. THEY HAVE ACHIEVED A FAR BETTER STATE OF AFFAIRS WITH RESPECT TO RELIABILITY AND SAFETY OF THEIR PLANTS THAN THIS COUNTRY HAS. AND, THEY HAVE ACCOMPLISHED THIS IN A DISCIPLINED MANNER AT REASONABLE COSTS.

I BELIEVE OUR COUNTRY WOULD BE SERVED WELL IF CONGRESS WERE TO MANDATE THAT DOE, OR ALTERNATIVELY NRC CONDUCT A SUBSTANTIAL RESEARCH AND/OR DEVELOPMENT PROGRAM AIMED AT PROVIDING SIGNIFICANT IMPROVEMENTS IN THE CURRENT GENERATION OF U.S. NUCLEAR POWER PLANTS. I ENVISION A PROGRAM THAT NOT ONLY INCLUDES THE AREAS IDENTIFIED ABOVE IN THE COMMISSION'S ANSWER BUT ONE THAT LEADS TO VIABLE DESIGNS FOR DEDICATED DECAY HEAT REMOVAL SYSTEMS, ENHANCED COPING CAPABILITY DURING STATION BLACKOUT, AND FILTERING AND VENTING CONTAINMENTS IN THE EVENT OF A CORE MELTDOWN.

QUESTION 4. If the NRC had the choice, what type of facility could it most use in terms of new safety research needs? If the facility were envisioned to be a "user" facility owned and operated by DOE (as has been the case in past safety research facilities), what other "users" might want to participate in the types of research that such a facility could offer?

ANSWER.

By the end of 1986 all U.S. thermal hydraulic test facilities will be shut down except the Babcock and Wilcox facility, which will still be available in 1987. Our choice for a new safety research facility would be an integral thermal hydraulic facility.

Congressional and administrative support via adequate appropriations beyond the current budget estimate of $99 million to be provided during FY 1987 would allow the NRC to proceed with detailed engineering and advanced procurements for the integral thermal hydraulics test facility at Idaho National Engineering Laboratory. These funds would allow RES to maintain a meaningful schedule in replacing aged test facilities and would afford the U.S. a new and expanded facility to investigate reactor off-normal conditions as they continue to occur in the future, in order to develop appropriate solutions to assure continued operational

QUESTION 4. (CONTINUED) -2-

SAFETY. ADVANCED PROCUREMENTS REQUIRING FUNDING IN FY 1987 WOULD INCLUDE SUCH LONG LEAD ITEMS AS PRESSURE VESSEL, PIPING, AND CORE INTERNALS.

IN ADDITION TO THE NRC AND DOE, OTHER USERS OF SUCH A FACILITY WOULD INCLUDE PLANT VENDORS, OWNERS GROUPS, AND OTHER, SIMILAR INDUSTRIAL OPGANIZATIONS. FOREIGN OWNERS OF U.S.-TYPE OR U.S.-BUILT PLANTS, MIGHT ALSO WANT TO PARTICIPATE.

IN ADDITION, THE NRC FEELS THAT EXISTING SEVERE ACCIDENT RESEARCH FACILITIES SHOULD BE PRESERVED. MOST OF THE NRC'S EXPERIMENTAL RESEARCH IS NOW DONE IN FACILITIES LOCATED AT THE SANDIA NATIONAL LABORATORY NEAR ALBUQUERQUE, NM. THE FINAL SEVERE FUEL DAMAGE TEST WAS DONE IN THE POWER BURST FACILITY AT IDAHO NATIONAL ENGINEERING LABORATORY (INEL) IN MARCH, 1985, AND THE FACILITY IS IN STANDBY STATUS AT PRESENT AWAITING DEACTIVATION AND DEFUELING.

AT SANDIA, NRC HAS SEVERAL HYDROGEN TEST FACILITIES IN WHICH THE TESTING WILL BE COMPLETED DURING FY 1986. THERE ARE NO PLANS NOR FUNDS AVAILABLE TO PRESERVE THESE FACILITIES. ALSO AT SANDIA THERE ARE SEVERAL EXPENSIVE TEST FACILITIES USED IN VARIOUS EXPERIMENTS TO MEASURE THE LOADS WHICH MIGHT BE PLACED ON A REACTOR CONTAINMENT FROM MOLTEN FUEL. TESTING IN THESE FACILITIES IS TO BE COMPLETED IN FY 1987. DUE TO A LACK OF FUNDS THERE ARE

NO PLANS TO PRESERVE THESE FACILITIES.

THE ONLY DOMESTIC IN-PILE SEVERE ACCIDENT TEST FACILITY WHICH NRC HAS AVAILABLE IS THE ANNULAR CORE RESEARCH REACTOR (ACRR) AT SANDIA. THIS FACILITY PERFORMS TESTS FOR DEFENSE PROGRAMS AND AVAILABILITY IS NOT DEPENDENT ON NRC RESEARCH FUNDING. WE HAVE ASSUMED THE FACILITY WILL REMAIN AVAILABLE BASED ON THE DOE DEFENSE TESTS FOR SEVERAL YEARS. HOWEVER, THE IN-CORE TEST VOLUME IS QUITE SMALL, AND THUS THERE ARE PROBLEMS OF SCALE. THIS FACILITY ALONE PROVIDES ONLY LIMITED DATA. DOE ALSO HAS A FACILITY IN IDAHO, THE TREAT REACTOR, IN WHICH LIMITED FUEL DAMAGE TESTS CAN BE CONDUCTED. NRC IS DEPENDENT ON DOE FOR THE CONTINUED AVAILABILITY OF THE ACRR AND THE TREAT REACTORS.

SEVERE ACCIDENT PHENOMENA EXPERIMENTS ARE PERFORMED IN FACILITIES LOCATED AT THE OAK RIDGE NATIONAL LABORATORY (ORNL), IN THE LACE FACILITY NEAR RICHLAND, WA, AND FACILITIES UNDER COOPERATIVE PROGRAMS IN CANADA AND W. GERMANY. NO PROVISION FOR RETENTION OF THESE FACILITIES BEYOND FY 1987 HAVE BEEN MADE.

WITHOUT SOME SPECIAL PROVISIONS TO APPROPRIATE FUNDS TO MAINTAIN THESE SEVERE ACCIDENT EXPERIMENTAL FACILITIES, THE U.S. WILL BE UNABLE TO RESPOND TO ANY INCIDENTS OR ACCIDENTS IN NUCLEAR POWER PLANTS WHICH WOULD REQUIRE EXPERIMENTAL DATA FOR RESOLUTION, WITH THE POSSIBLE EXCEPTION OF THE ACRR AND TREAT REACTORS (WITH THEIR LIMITS AS NOTED ABOVE).

QUESTION 4. (CONTINUED) -4-

COMMISSIONER ASSELSTINE ADDS THE FOLLOWING:

I BELIEVE RESEARCH FACILITIES NECESSARY TO SUPPORT THE KINDS OF IMPROVED SAFETY RESEARCH DESCRIBED IN MY RESPONSE TO QUESTION 3 SHOULD HAVE THE HIGHEST PRIORITY.

QUESTION 5. How does Nuclear Regulatory Research (RES) provide a benefit to the taxpayer? How are the results of the research applied? Has it been factored into the utility system, allowing an increase in operations? Has it contributed to the construction and operation of safer reactors by contributing to regulatory decisions?

ANSWER.

See Response to Question 1.

QUESTION 6. RES HAS TAKEN SEVERE BUDGET CUTS OVER THE PAST FOUR OR FIVE YEARS. HOW IS THE COMMISSION ASSISTING RES IN DETERMINING WHAT RESEARCH MUST BE DONE, AND HOW TO BEST USE THE RESEARCH PROGRAMS THAT REMAIN?

ANSWER.

THE NRC HAS REDUCED ITS RESEARCH PROGRAM SIGNIFICANTLY IN THE PAST SEVERAL YEARS, PARTLY BECAUSE OF THE COMPLETION OF SOME MAJOR PROJECTS LIKE LOFT, BUT MOSTLY TO CONFORM TO THE DECLINING BUDGET.

THE COMMISSION IS ATTENTIVE TO AND SUPPORTIVE OF THE NRC RESEARCH PROGRAM. A SIGNIFICANT PART OF THE COMMISSION'S FEBRUARY 19, 1986 TESTIMONY BEFORE THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, WAS DEVOTED TO THE NEED FOR A STABLE, PROPERLY BALANCED, ADEQUATELY FUNDED RESEARCH PROGRAM. THE CHAIRMAN AND COMMISSIONERS HAVE REPEATEDLY ADDRESSED THE NEED FOR A STABLE, ONGOING NRC RESEARCH PROGRAM TO RESOLVE REGULATORY ISSUES AND NEW PROBLEMS AS THEY ARISE. TO CITE AN EXAMPLE, ON JULY 8, 1985, CHAIRMAN PALLADINO, IN REMARKS TO THE INTERNATIONAL CONFERENCE ON NUCLEAR POWER PLANT AGING, AVAILABILITY FACTOR, AND RELIABILITY ANALYSIS, STRESSED THE NEED FOR SAFETY RESEARCH ON THE SUBJECT OF NUCLEAR PLANT AGING, PARTICULARLY TO IDENTIFY AND CHARACTERIZE AGING AND SERVICE WEAR IN OPERATING NUCLEAR POWER PLANTS AND TO RECOMMEND METHODS FOR INSPECTION, SURVEILLANCE, AND

MONITORING OF AGING AND SEVERE WEAR EFFECTS BEFORE SAFETY FUNCTIONS ARE IMPAIRED SO THAT PROPER MAINTENANCE AND TIMELY REPAIR OR REPLACEMENT CAN BE IMPLEMENTED.

THE COMMISSION PROVIDES DIRECTION TO THE RESEARCH PROGRAM THROUGH ITS POLICY AND PLANNING GUIDANCE (NUREG-0885) AND THROUGH THE BUDGET PROCESS, BOTH OF WHICH ESTABLISH THE FRAMEWORK IN WHICH THE PROGRAM OPERATES. QUARTERLY COMMISSION BRIEFINGS ON THE RESEARCH PROGRAM ARE BEING INITIATED TO FACILITATE COMMISSION GUIDANCE TO THE STAFF REGARDING SPECIFIC RSEARCH AREAS.

RESEARCH HAS ALSO PREPARED A LONG RANGE RESEARCH PLAN WHICH IS USED TO DEFINE THE OBJECTIVES AND TIMETABLES FOR RESEARCH PROJECTS. THE COMMISSION HAS TAKEN AN ACTIVE INTEREST IN THIS PLAN.

QUESTION 7. WHAT ARE THIS NATION'S MOST CRITICAL RESEARCH NEEDS, NOW AND FOR THE FUTURE OF NUCLEAR REACTORS? WHY? HOW DOES THE NRC OFFICE OF RESEARCH PLAN TO MEET THESE NEEDS?

ANSWER.

FROM NRC'S REGULATORY PERSPECTIVE, THE MOST CRITICAL RESEARCH NEEDS CONFRONTING THE SAFE OPERATION OF THE U.S. NUCLEAR INDUSTRY ARE THE FOLLOWING SIX MAJOR RESEARCH AREAS:

- AGING AND DEGRADATION OF OPERATING NUCLEAR POWER PLANTS

  CORROSION, RADIATION EMBRITTLEMENT, AND FATIGUE HAVE RAISED SPECIFIC QUESTIONS ABOUT THE CONTINUED SAFETY AND VIABILITY OF MANY OPERATING REACTORS; IN PARTICULAR, CONCERNS WITH THE INTEGRITY OF THE PRIMARY COOLANT PRESSURE BOUNDARY, CRACKED PIPING, DEFECTIVE VALVES AND RELAYS HAVE BEEN RAISED. ANTICIPATED PROPOSALS FOR PLANT-LIFE EXTENSION ARE EXPECTED TO REQUIRE EXAMINATION IN AREAS SUCH AS: IMPROVEMENT OF SURVEILLANCE AND TEST METHODS FOR COMPONENTS OR SYSTEMS, UPGRADING THE RELIABILITY OF KEY COMPONENTS OR SYSTEMS, DEVELOPING GOOD RELIABILITY ASSURANCE PROGRAMS, AND MAKING THE MODIFICATIONS THAT COME TO LIGHT FROM RESOLUTION OF SAFETY ISSUES.

QUESTION 7. (CONTINUED) -2-

- OPERATIONAL AND THERMAL HYDRAULIC TRANSIENTS

UNLESS ACTION IS TAKEN, THE NRC WILL NO LONGER HAVE THE ABILITY TO EVALUATE RESPONSES OF NUCLEAR POWER PLANTS TO OPERATIONAL TRANSIENTS WITH BROAD SAFETY IMPLICATIONS OR ASSESS INDUSTRY PROPOSED CHANGES TO CORRECT DEFICIENCIES. THE NRC STAFF BELIEVES THAT IT IS NECESSARY TO RETAIN A BROAD REACTIVE CAPABILITY TO RESPOND TO INCIDENTS AS THEY ARISE. WITH NEARLY 100 PLANTS OPERATIONAL IN THE UNITED STATES AND SEVERAL HUNDRED IN OTHER COUNTRIES, SIGNIFICANT UNANTICIPATED OR UNANALYZED TRANSIENTS CONTINUE TO OCCUR.

NRC NEEDS A TECHNICAL BASIS TO UNDERSTAND ACTUAL EVENTS AND THEIR IMPLICATIONS AND TO RESOLVE SAFETY ISSUES. IN EACH CASE, THE NRC MUST PERFORM ANALYSES TO EVALUATE THE EVENT WITH RESPECT TO THE PLANT AT WHICH IT OCCURRED AND FOR PLANTS OF SIMILAR DESIGN. EXPERIMENTAL PROGRAMS ARE REQUIRED SINCE THE EVENT OR ISSUE IS FREQUENTLY SUFFICIENTLY DIFFERENT FROM EVENTS PREVIOUSLY EVALUATED THAT EXPERIMENTAL CONFIRMATION OF THE COMPUTER CODE APPLICABILITY IS REQUIRED. EVEN THOUGH OUR COMPUTER CODES HAVE BEEN ASSESSED FOR A WIDE RANGE OF ACCIDENTS AND TRANSIENTS, THE NRC STAFF BELIEVES THAT IT IS NECESSARY TO MAINTAIN EXPERIMENTAL CAPABILITIES APPLICABLE TO THE MAJOR CURRENT COMMERCIAL REACTOR DESIGNS TO ASSURE THE NECESSARY CONFIDENCE TO ASSESS SAFETY ISSUES.

QUESTION 7. (CONTINUED) -3-

- SEVERE ACCIDENTS AND THEIR REGULATORY IMPLICATIONS

  IMPLEMENTATION OF THE COMMISSION'S POLICY ON SEVERE REACTOR ACCIDENTS REQUIRES A THOROUGH UNDERSTANDING OF THE PHYSICAL AND CHEMICAL PROCESSES WHICH TAKE PLACE DURING SUCH ACCIDENTS AND ON THEIR POTENTIAL IMPACTS ON PUBLIC HEALTH AND SAFETY. INFORMATION IS BEING DEVELOPED TO PROVIDE THE TECHNICAL BASIS NEEDED TO REVISE CURRENT REGULATORY REQUIREMENTS AND TO ASSESS THE NEED TO BACKFIT ADDITIONAL SAFETY FEATURES ON OPERATING PLANTS.

- PLANT OPERATIONS AND RISK ASSESSMENT

  UNDERSTANDING THE RISK REDUCTION POTENTIAL OF VARIOUS EXISTING AND PROPOSED REGULATORY REQUIREMENTS AND THE RISK REPRESENTED BY SPECIFIC REACTOR CONDITIONS IS REQUIRED TO ESTABLISH THE LIMITING CONDITIONS FOR REACTOR OPERATION.

- SEISMIC DESIGN ANALYSIS

  THERE IS A NEED FOR IMPROVED BASES AND METHODS FOR PROPERLY CHARACTERIZING SEISMIC HAZARD AND SEISMIC MARGINS FOR NUCLEAR POWER PLANTS IN THE EASTERN U.S.

- NUCLEAR WASTE DISPOSAL

  THIS INVOLVES ISSUES RELATED TO WASTE FORM, WASTE PACKAGE INTEGRITY, AND REPOSITORY PERFORMANCE. RESEARCH IS REQUIRED TO ENSURE THAT REGULATORY CRITERIA ARE APPROPRIATE TO PERMIT A SOUND EVALUATION OF PROPOSALS FOR REPOSITORIES AND ASSURE THAT ALL REGULATORY REQUIREMENTS WILL BE MET.

THE NRC RESEARCH PROGRAM IS FOCUSSED ON THESE HIGH PRIORITY SAFETY ISSUES AND IS CAREFULLY STRUCTURED TO FOCUS ONLY ON THOSE TECHNICAL AREAS WHERE AN INDEPENDENT NRC CAPABILITY IS NECESSARY IN ORDER FOR NRC TO PERFORM ITS REQUIRED FUNCTIONS OF PROTECTING PUBLIC HEALTH AND SAFETY. RECENT EXAMPLES WHERE RESEARCH MADE IT POSSIBLE TO MAKE PROMPT TECHNICAL DECISIONS ARE IN THE AREAS OF REACTOR VESSEL BRITTLE FRACTURE, AND FOR CRACKING IN LARGE PIPES.

THE NRC RESEARCH PROGRAMS TO MEET THESE NEEDS ARE DESCRIBED IN NRC'S FY 1987 BUDGET REQUEST SUBMITTED TO CONGRESS IN FEBRUARY 1986 (NUREG-1100, VOLUME 2). RES PROVIDES SUPPORT TO THESE PROGRAMS THROUGH APPROPRIATE FUNDS AND INCREASED COLLABORATIVE RESEARCH EFFORTS INVOLVING PARTIES SUCH AS OTHER GOVERNMENT AGENCIES, THE NUCLEAR INDUSTRY AND FOREIGN ORGANIZATIONS.

COMMISSIONER ASSELSTINE ADDS THE FOLLOWING:

I BELIEVE THIS NATION'S MOST CRITICAL RESEARCH NEEDS NOW AND FOR THE FUTURE OF NUCLEAR REACTORS WAS IDENTIFIED IN THE KEMENY COMMISSION REPORT TO THE PRESIDENT REGARDING TMI-2 ACCIDENT OVER SEVEN YEARS AGO. THAT COMMISSION WROTE:

> WHETHER IN THIS PARTICULAR CASE WE CAME CLOSE TO A CATASTROPHIC ACCIDENT OR NOT, THIS ACCIDENT WAS TOO SERIOUS. ACCIDENTS AS SERIOUS AS TMI SHOULD NOT BE ALLOWED TO OCCUR IN THE FUTURE.
>
> THE ACCIDENT GOT SUFFICIENTLY OUT OF HAND SO THAT THOSE ATTEMPTING TO CONTROL IT WERE OPERATING SOMEWHAT IN THE DARK. WHILE TODAY THE CAUSES ARE WELL UNDERSTOOD, 6 MONTHS AFTER THE ACCIDENT IT IS STILL DIFFICULT TO KNOW THE PRECISE STATE OF THE CORE AND WHAT THE CONDITIONS ARE INSIDE THE REACTOR BUILDING. ONCE AN ACCIDENT REACHES THIS STAGE, ONE THAT GOES BEYOND WELL-UNDERSTOOD PRINCIPLES, AND PUTS THOSE CONTROLLING THE ACCIDENT INTO AN EXPERIMENTAL MODE (THIS HAPPENED DURING THE FIRST DAY), THE UNCERTAINTY OF WHETHER AN ACCIDENT COULD RESULT IN MAJOR RELEASES OF RADIOACTIVITY IS TOO HIGH. ADDING TO THIS THE ENORMOUS DAMAGE TO THE PLANT, THE EXPENSIVE AND POTENTIALLY DANGEROUS CLEANUP PROCESS THAT REMAINS, AND THE GREAT COST OF THE ACCIDENT, WE MUST CONCLUDE THAT -- WHATEVER WORSE COULD HAVE HAPPENED -- THE ACCIDENT HAD ALREADY GONE TOO FAR TO MAKE IT TOLERABLE.
>
> WHILE THROUGHOUT THIS ENTIRE DOCUMENT WE EMPHASIZE THAT FUNDAMENTAL CHANGES ARE NECESSARY TO PREVENT ACCIDENTS AS SERIOUS AS TMI, WE MUST NOT ASSUME THAT AN ACCIDENT OF THIS OR GREATER SERIOUSNESS CANNOT HAPPEN AGAIN, EVEN IF THE CHANGES WE RECOMMEND ARE MADE. THEREFORE, IN ADDITION TO DOING EVERYTHING TO PREVENT SUCH ACCIDENTS, WE MUST BE FULLY PREPARED TO MINIMIZE THE POTENTIAL IMPACT OF SUCH AN ACCIDENT ON PUBLIC HEALTH AND SAFETY, SHOULD ONE OCCUR IN THE FUTURE.
>
> REPORT OF THE PRESIDENT'S COMMISSION ON THE ACCIDENT AT THREE MILE ISLAND, P.15.

SOME OF OUR CURRENT RESEARCH PROGRAM IS HELPFUL IN MEETING THIS RECOMMENDATION BUT SOME OF THE COMMISSION'S POLICIES, PRACTICES AND RULES ARE NOT HELPFUL. IT IS IMPORTANT TO HEED THE ADVICE OF THE KEMENY COMMISSION BECAUSE ANOTHER SEVERE ACCIDENT MAY WELL BRING TO A HALT FURTHER DEVELOPMENT OF THE NUCLEAR INDUSTRY, AND IF PEOPLE ARE INJURED, MAY WELL JEOPARDIZE CONTINUED OPERATION OF EXISTING REACTORS. THE MATTER COMES DOWN TO WHETHER THE PUBLIC AND THE CONGRESS WILL TOLERATE ANOTHER SEVERE ACCIDENT. I THINK NOT. FOR AREAS OF NEEDED RESEARCH, SEE MY RESPONSES TO QUESTIONS 3 AND 4.

WITH REGARD TO A FUTURE GENERATION OF NUCLEAR REACTORS, MY VIEWS ARE SET FORTH IN THE ATTACHED.

NOTATION VOTE

RESPONSE SHEET

TO: SAMUEL J. CHILK, SECRETARY OF THE COMMISSION

FROM: COMMISSIONER ASSELSTINE

SUBJECT: SECY-85-279 - REVISED ADVANCED REACTOR POLICY STATEMENT

APPROVED_____ DISAPPROVED_✓_____ ABSTAIN_____

NOT PARTICIPATING_____ REQUEST DISCUSSION_____

COMMENTS:

DISSENTING VIEWS ARE ATTACHED.

SIGNATURE

	YES	NO
Entered on "AS"	☐	☐

4-17-86
DATE

SECRETARIAT NOTE: PLEASE ALSO RESPOND TO AND/OR COMMENT ON OGC/OPE MEMORANDUM IF ONE HAS BEEN ISSUED ON THIS PAPER.

NRC-SECY FORM DEC. 80

Dissenting Views of Commissioner Asselstine

I do not believe that this advanced reactor policy statement provides the sound regulatory basis needed to support a new generation of nuclear power plants in this country. This policy statement encourages, but does not require, safety improvements in advanced reactor design, and expresses a willingness on NRC's part to conduct safety reviews of advanced reactor design concepts so that NRC will be in a position to act on any future plant or design license application. The primary decision made in developing this policy is the commitment to maintain a small advanced reactor group within the Agency that would serve as the focal point for interaction with reactor design groups. However it appears that even this commitment may be in jeopardy given current budgetary constraints.

I believe that more is needed to articulate an effective regulatory policy and to ensure a successful program for future nuclear power plants in this country, whether those plants are of a type similar to current light water reactors or whether they are of more fundamentally different design. Such a policy should reconsider the Commission's regulatory practices of the past thirty years. Those past practices can be characterized as primarily a reactive regulatory regime to what the designers propose. It leaves resolution of issues to what one industry executive has called the rough, tough surly competitive elements. Safety systems are limited because of cost considerations. Containment capabilities are minimized to reduce costs. Core power densities have been driven to the limits of materials capabilities and our understanding of decay heat removal phenomena. And

the balance of plant is designed to lower standards than the reactor systems to minimize costs. These competitive forces are what led to the level of safety achieved in the current generation of nuclear power plants and are in part responsible for the poor performance of some of our plants.

The NRC and AEC before it have often avoided developing stringent specifications or design requirements because of a fear that if the Commission were to be too specific in its requirements, the emerging industry might be slowed in its growth and innovation might be discouraged. That argument might have had some validity in the 1960's and 1970's when the current generation of reactors was being designed without the benefit of significant operating experience or data. However, now that we have considerable worldwide experience with a large variety of nuclear reactor designs, I believe it is time for NRC to become more proactive in what it will require of future generations of reactors.

Following the TMI-2 accident, the notion of a demarcation between the current generation of plants and a future generation of plants was raised, with the distinction that the latter would be designed based on a reformulation of the Siting Criteria and General Design Criteria to reflect all that had been learned over the years, including the broader lessons of TMI-2. Thus, the TMI Action Plan was developed with the current generation of plants in mind, leaving open the question of possible broader changes for a future generation of plants. One such broad change could be to go beyond the so-called single failure criterion which experience shows may

not be serving us well. The June 9, 1985 accident at Davis-Besse is a case in point where 14 separate failures occurred.

Many foreign countries are requiring four independent trains of safety systems whereas NRC requires only two. When NRC reviews advanced designs such as the one being jointly developed by a U.S. vendor and a foreign country, the NRC staff does not require as prudent additional safety features being required by the foreign country. Rather, Commission practices and procedures require a cost-benefit analysis to justify any additional safety feature. This analysis is typically incomplete and often crude. Furthermore, the Commission gives little consideration to the enormous uncertainties in reactor risks in its decisionmaking process. This approach to reactor safety needs improvement.

There has been insufficient thought and effort in developing a map for the future. The Advanced Reactor Policy Statement provides no guidance on what containment capabilities will be required; on whether the single failure criterion is adequate for the future; on acceptable core power densities (an issue which has significant bearing on the core meltdown risks to the public); and on the root causes of the core meltdown risks that might be addressed by design improvements in a future generation of reactors. Nor is there guidance on what standards the balance of plant must meet. Nothing is said about the fuel cycle and the process for licensing the fuel cycle associated with some of the advanced designs currently being examined. For example, when and in what way will the Commission reopen the aborted proceeding on plutonium recycle. And, finally the Commission gives

essentially no guidance on whether a prototypical plant will be required before allowing widespread use of that design. I would have expected that NRC would approach a future generation of nuclear power plants with an attitude of correcting past weaknesses. Unfortunately, the Advanced Reactor Policy Statement does not reflect that kind of attitude.

Other countries with extensive nuclear power programs appear to be designing, constructing, operating and maintaining better nuclear power plants than those of this country. Foreign countries are demanding more safety and reliability in their current generation of plants than the NRC is requiring of the U.S. plants. Yet, this Advanced Reactor Policy Statement accepts the next generation of U.S. power plants if such a design provides a level of safety equivalent to that achieved in the U.S. designs that were completed over 10 years ago. I do not think such a policy serves the country well. My concern is not merely that we should keep up with others. Rather, my concern is that the current generation of plants is still surprising us in their performance. As the Commission has recently acknowledged to the Congress, the current generation of nuclear power plants in this country can best be characterized as a complex technology that is not fully mature. There remain great uncertainties in the level of risk they pose to the public. In such circumstances, I believe prudent decisionmaking should come down on the side of improved safety, not only for the current generation of plants but for the next generation as well.

If there is to be a future generation of nuclear power plants and if the nuclear option is to be an important element of the nation's future energy

mix, then the NRC, the vendors, the utilities, and the Congress must ensure that the next generation of power plants is substantially better than the current generation. The next generation of plants should be more reliable, more forgiving, simpler, easier to construct, easier to operate, and easier to maintain than the current generation. Any design that does not accomplish this is not acceptable in my view. I say this for a straightforward reason. We cannot afford to will to the future reactor designs that have a fifty percent chance of a core meltdown every ten to twenty years in a population of 100 reactors. We should not will to the future the great uncertainties in safety levels that exist today. Nor should we will to the future consumer reactor designs that have a 50 to 60 percent capacity factor.

We must step back and examine the strengths and weaknesses of past and current designs and the approaches taken in getting where we are today. Only then, in my view, can we intelligently map a course for the future. I am encouraged that there is a segment within the industry that is undertaking a fresh look at the nuclear technology. The forward-looking members of the industry are attempting to generate a set of requirements that, from the standpoint of the utilities, must be met before utilities will consider placing new orders. I find it disappointing that the NRC is unwilling to generate a set of safety requirements for the next generation of power plants.

QUESTION 8. DURING THE PAST TWO YEARS, THE NRC HAS MADE AN EFFORT TO CENTER PREVIOUSLY SCATTERED RESEARCH IN SPECIFIC AREAS AT CERTAIN LABORATORIES. WHAT IS THE STATUS OF THIS PROGRAM, REFERRED TO AS "TECHNICAL INTEGRATION CENTERS"? WHAT IS THE FUNDING SUPPORT PROVIDED FOR IT IN FY87?

ANSWER.

NRC HAS BEGUN IMPLEMENTATION OF TECHNICAL INTEGRATION IN FOUR PILOT AREAS, THERMAL-HYDRAULICS, PLANT AGING, DECOMMISSIONING AND PLANT MAINTENANCE. THIS IS TO ASSURE INTEGRATION OF THESE DISCIPLINES THROUGHOUT THE NRC OFFICES AND REGIONS INVOLVED IN THE PARTICULAR DISCIPLINES. THERMAL-HYDRAULICS IS THE MOST MATURE OF THESE IN THAT THE IDAHO NATIONAL ENGINEERING LABORATORY (INEL) HAS BEEN DESIGNATED AS THE FIRST NRC TECHNICAL INTEGRATION CENTER (FOR THERMAL-HYDRAULICS) AS OF FEBRUARY, 1986.

A SIGNIFICANT PORTION OF THE NRC THERMAL-HYDRAULIC WORK WILL BE CONSOLIDATED AT INEL TO TAKE ADVANTAGE OF THE NATIONS LARGEST REMAINING STAFF OF THERMAL-HYDRAULIC EXPERTS AND TEST CAPABILITIES. WHILE CERTAIN WORK WILL CONTINUE TO BE PERFORMED AT OTHER ORGANIZATIONS, SUCH AS LANL AND UNIVERSITY PROGRAMS, WHERE SPECIALIZED EXPERTISE EXISTS, INEL WILL MAINTAIN COGNIZANCE AND ASSURE INTEGRATION. THE TECHNICAL INTEGRATION CENTER

QUESTION 8. (CONTINUED) - 2 -

WOULD BE RESPONSIBLE TO PROVIDE TECHNICAL INTEGRATION SERVICES TO ABOUT $7.9 MILLION WORTH OF RESEARCH AT INEL DURING FY 1987.

IN ADDITION, ACTIVITIES ARE UNDERWAY TO ASSESS THE FEASIBILITY OF EXPANDING THIS INTEGRATION CENTER TO ADDRESS OPERATIONAL SAFETY. IN AN EFFORT TO ENHANCE REGULATORY UTILIZATION OF RESEARCH, THIS CONCEPT WILL INTEGRATE THE APPLICATION OF EXPERTISE IN THERMAL HYDRUALICS AND OTHER DISCIPLINES SUCH AS RISK ANALYSIS AND HUMAN RELIABILITY TO PROVIDE A RESPONSE CAPABILITY TO REACTOR SAFETY ISSUES. THIS WOULD RAISE THE FY 1987 TOTAL OF TECHNICAL INTEGRATION SERVICES AT INEL TO $10.6 MILLION.

QUESTION 9. WHAT ARE NRC'S RESEARCH PRIORITIES FOR THE NEXT FOUR YEARS? WHAT IS THE REASON FOR THE RANKING?

ANSWER.

THE NRC RESEARCH PROGRAM IS ARRANGED INTO SIX RESEARCH AREAS: ENGINEERING; SEVERE ACCIDENTS; THERMAL HYDRAULICS; RISK; SEISMIC; AND WASTE MANAGEMENT. THESE REPRESENT THE HIGHEST PRIORITY AREAS FOR RESEARCH. AT PRESENT WE DO NOT PRIORITIZE OR PUT INTO ANY ORDER OF RANKING THESE SIX AREAS, AS THEY ARE ALL REQUIRED. KEY CONSIDERATIONS FOR THE ORDERING OF RESEARCH PRIORITIES WITHIN EACH PROGRAM AREA ARE RISK RELEVANCE AND REGULATORY SIGNIFICANCE. RISK RELEVANCE IS INDICATED BY THE DEGREE TO WHICH THE RESEARCH WILL CONTRIBUTE TO THE RISK-REDUCTION POTENTIAL AND THE DEGREE TO WHICH UNCERTAINTIES CAN BE IDENTIFIED AND REDUCED. REGULATORY SIGNIFICANCE IS INDICATED BY THE RELEVANCE AND TIMELINESS OF RESEARCH RESULTS FOR THE RESOLUTION OF REGULATORY ISSUES. THESE DETERMINATIONS ARE MADE IN EXTENSIVE INTERFACES BETWEEN OFFICE OF RESEARCH STAFF AND THE STAFF OF USER PROGRAM OFFICES.

PRIORITIZING RESEARCH ACTIVITIES HAS PRESENTED A COMPLEX TASK IN RECENT YEARS OF DECLINING RESOURCES WITH AN AGENDA OF IMPORTANT SAFETY ISSUES TO BE ADDRESSED. IN OUR EFFORTS TO REFINE AND IMPROVE THE PRIORITIZATION OF RESEARCH ACTIVITIES WE ARE PRESENTLY DEVELOPING AND TESTING A MORE SOPHISTICATED PRIORITIZATION SCHEME BASED ON REGULATORY SIGNIFICANCE OF UNCERTAINTIES, RISK RELEVANCE, MAINTENANCE

OF EXPERTISE, AND ABILITY TO UNCOVER UNRECOGNIZED SAFETY PROBLEMS. THIS SYSTEM IS STILL UNDER DEVELOPMENT, HOWEVER, AND IS NOT YET USABLE FOR MAKING DECISIONS.

IT IS IMPORTANT TO OBSERVE THAT THE BUDGET LEVEL IN FY 1987 IS AT A REDUCED LEVEL RELATIVE TO PRIOR YEARS SUCH THAT NOT ALL OF THE PROGRAM OFFICE REQUESTS ARE BEING SATISFIED. ALSO, SEVERAL IMPORTANT RESEARCH AREAS (RADIATION PROTECTION, CHEMICAL ENGINEERING, AND ELECTRICAL ENGINEERING) ARE DISCONTINUED IN FY 1987. HENCE, ONLY THE HIGHEST PRIORITY TASKS WILL BE FUNDED.

QUESTION 10. DOES NRC COORDINATE ANY OF ITS RESEARCH PROGRAMS WITH DOE?

ANSWER.

TWO AREAS IN WHICH THE NRC AND DOE HAVE SUCCESSFULLY CONDUCTED COMPLEMENTARY RESEARCH ARE THE ANALYSIS OF FISSION PRODUCT TEST DATA FROM THE LOFT PROGRAM AND THE EPRI-SPONSORED TREAT PROGRAM. WHILE THE PARTIES PARTICIPATING HAD DIFFERENT RESEARCH OBJECTIVES, THESE COORDINATED RESEARCH PROGRAMS WERE ABLE TO SATISFY THE NEEDS OF ALL PARTICIPANTS. ADDITIONALLY, IN THE AREA OF SEVERE FUEL DAMAGE, NRC HAS CONSIDERED DOE'S TMI-2 DATA IN FORMULATING ITS OWN PROGRAM.

QUESTION 11. On page 2 of your statement you say, "NRC's major concern is that the technical infrastructure that supports progress in safe production of nuclear power not be FURTHER eroded." (Emphasis added.) How has the technical infrastructure that supports progress in safe production of nuclear power "been eroded" to date? Please be specific.

ANSWER.

The NRC in-pile testing was carried out at the Power Burst Facility (PBF) and the Loss-of-Flow-Test (LOFT) facility at Idaho National Engineering Laboratory. The facilities have now been shutdown, and the technical staffs associated with them have been disbanded. Now the NRC must depend on the Annular Core Research Reactor (ACRR), at Sandia. The ACRR is a test reactor used mainly for defense programs, but with only limited capability for small-scale fuel testing. While the loss of the facilities is detrimental to the NRC's ability to conduct future research, even worse is the loss of technical skills associated with these facilities. These skills cannot be replaced in a short time.

In another area, we have curtailed our support of noise diagnostics, and these experts are generally not available. Such support was of considerable benefit to the agency in the TMI-2 response, and in other reactor abnormal occurrences over the past

QUESTION 11. (CONTINUED) - 2 -

DECADE. WITH THE DIMINUTION OF PROGRAMS IN EQUIPMENT QUALIFICATION AND FIRE SAFETY, WE ARE SEEING EROSION OF THE INFRASTRUCTURE IN THESE AREAS.

MEMBERS OF THE RESEARCH STAFF MEET PERIODICALLY DURING THE YEAR WITH THE MEMBERS OF THE NUCLEAR ENGINEERING DEPARTMENT HEADS ORGANIZATION (NEDHO) TO DISCUSS NEEDED RESEARCH. WE ARE CONCERNED BY THE REDUCTION OF U.S. CITIZENS ENROLLED IN NUCLEAR ENGINEERING GRADUATE PROGRAMS, ESPECIALLY AT THE DOCTORATE LEVEL. THIS MEANS THAT THERE WILL BE A SIGNIFICANT SHORTAGE OF NEW TALENT AVAILABLE IN THE NEAR FUTURE.

QUESTION 12. WHAT IS THE PROPER MIX BETWEEN THE NUCLEAR SAFETY RESEARCH CARRIED OUT BY DOE AND THAT CARRIED OUT BY NRC? HOW SHOULD RESEARCH TOPICS, TYPES OF RESEARCH SUPPORT AND MISSIONS BE DIVIDED UP AMONG THE TWO AGENCIES? WHAT DUPLICATION OF EFFORT IS THERE, IF ANY?

ANSWER.

WITH REGARD TO THE PROPER MIX AND DIVISION OF RESEARCH BETWEEN DOE AND NRC, BOTH AGENCIES HAVE MAJOR ROLES IN PERFORMING SAFETY RESEARCH, AND HAVE AN INTEREST IN MAINTAINING U.S. TEST FACILITIES AND TECHNICAL CAPABILITIES. THE NRC SEES THE FOLLOWING SIX MAJOR AREAS OF SAFETY CONCERN THAT REQUIRE TECHNICAL SUPPORT: (1) AGING AND DEGRADATION IN SERVICE; (2) SYSTEM RESPONSE TO COMPLEX OPERATIONAL AND THERMO-HYDRAULIC TRANSIENTS; (3) SEVERE ACCIDENT ISSUES; (4) REACTOR OPERATION AND RISK ASSESSMENT; (5) SEISMIC DESIGN ANALYSIS; AND (6) NUCLEAR WASTE DISPOSAL. (THESE SIX AREAS ARE ADDRESSED IN THE RESPONSE TO QUESTION 7.)

NRC'S RESEARCH PROGRAM IN THE ABOVE AREAS FOCUSES ON REGULATORY NEEDS TO PROTECT PUBLIC HEALTH AND SAFETY. IT IS ORIENTED TOWARDS RESOLUTION OF CURRENT OR POTENTIAL REGULATORY PROBLEMS.

QUESTION 12 (CONTINUED) - 2 -

THE DOE PROMOTES THE USE OF NUCLEAR POWER AND ITS RESEARCH IS FOCUSED UPON AREAS SUCH AS RELIABILITY OF OPERATION, ADVANCED DEVELOPMENT, AND IMPROVED ECONOMICS OF PLANT OPERATION, E.G., EXTENDED FUEL BURNUP.

QUESTION 13. WHAT IS YOUR VIEW OF THE POTENTIAL OF EXTENDED FUEL BURNUP TO REDUCE THE AMOUNT OF SPENT FUEL THAT MUST BE DELIVERED TO REPOSITORIES? IS ADDITIONAL FEDERAL RESEARCH SUPPORT FOR EXTENDED BURNUP DESIRABLE?

ANSWER.

WE UNDERSTAND FROM OUR CONTACTS WITH THE DOE RESEARCH PROGRAM ON EXTENDED BURNUP FUEL THAT A REDUCTION OF AS MUCH AS 40 PERCENT IN FUEL DELIVERED TO REPOSITORIES MAY BE EXPECTED. IN NRC WE HAVE STARTED TO LOOK AT THE ENVIRONMENTAL AND SAFETY ASPECTS OF THE STORAGE OF EXTENDED BURNUP FUEL BUT NO RESULTS ARE YET AVAILABLE. LICENSEES HAVE IN GENERAL TAKEN A CONSERVATIVE APPROACH BY EXTENDING THE BURNUP OF THEIR FUEL BY A LITTLE WITH EACH RELOAD. APPROXIMATELY 10 PERCENT HAVE EXCEEDED A BURNUP LEVEL OF 38,000 MWD/TON AT WHICH POINT THEY MUST SUBMIT A REANALYSIS OF FUEL HANDLING ACCIDENTS WHICH MAY OCCUR DURING REFUELING. TO PUT THIS NUMBER IN PERSPECTIVE, INITIAL FUEL BURNUPS WERE IN THE 25,000 TO 33,000 MWD/TON A DECADE AGO AND SOME PLANTS ARE HOPING TO ACHIEVE 60,000 OR MORE MWD/TON SOME TIME IN THE FUTURE.

THE REGULATORY CONCERNS MAINLY CENTER AROUND THE GREATER RELATIVE QUANTITIES OF RADIONUCLIDES OF LONG HALF LIFE SUCH AS PLUTONIUM. THE RADIONUCLIDES OF IMPORTANCE TO HEALTH EFFECTS FROM ACCIDENTS SUCH AS IODINE 131 OR CESIUM 137 TEND TO LEVEL OFF IN QUANTITY AS

THE FUEL REMAINS IN THE REACTOR SO THAT HIGH BURNUP FUEL WOULD NOT BE EXPECTED TO HAVE GREATER QUANTITIES OF THESE FISSION PRODUCTS THAN FUELS WHICH ARE IN THE NORMAL BURNUP RANGE. SOME ADDITIONAL RESEARCH BY DOE MAY BE NECESSARY TO SPEED THE PROCESS TO REDUCE THE FUEL IN STORAGE. THE REDUCED QUANTITY OF FUEL IN STORAGE WOULD BE A BENEFIT TO OVERALL SAFETY.

ON THE QUESTION OF INCREASED SUPPORT OF RESEARCH TO EXTEND BURNUP, NRC FEELS THAT THE INFORMATION GATHERED FROM TEST ASSEMBLIES WHICH HAVE BEEN PLACED IN LICENSEE REACTORS OVER THE PAST 10 TO 12 YEARS HAVE PROVIDED SUFFICIENT BACKGROUND FOR REGULATION CONSIDERING THE SLOW PACE BEING TAKEN BY THE ELECTRIC UTILITY INDUSTRY TO EXTEND THE BURNUP OF THEIR FUEL.

QUESTION 14. WHAT INFORMATION CAN YOU PROVIDE ABOUT THE ACCIDENT THAT HAS APPARENTLY TAKEN PLACE NEAR KIEV IN THE UKRAINE?

ANSWER.

ON MAY 6, 1986, THE ASSOCIATED PRESS REPORTED THAT THE SOVIET GOVERNMENT STATED THAT ON APRIL 26, 1986 AT 1:23 A. M., THE INITIAL CHEMICAL EXPLOSION OCCURRED AS THE PLANT WAS GOING INTO A PLANNED SHUTDOWN. BASED ON RADIOLOGICAL MEASUREMENTS REGARDING THE RELATIVE RATIOS OF IODINE-133, THE NRC STAFF HAS CALCULATED THAT THE PLANT WAS SHUT DOWN AT APPROXIMATELY MIDNIGHT, APRIL 25TH. THIS IS CONSISTENT WITH THE SOVIETS' STATEMENT AND WE ARE NOT AWARE OF ANY OTHER INFORMATION WHICH CONFLICTS WITH THIS REPORT.

BASED ON THE MOST CURRENT INFORMATION AVAILABLE, THE FOLLOWING IS OUR UNDERSTANDING OF THE STATUS OF THE PLANT AND SITE:

- UNIT 4 REACTOR BUILDING IS DESTROYED.
- RADIOLOGICAL RELEASES CONTINUE FROM THE PLANT, AT LEVELS MUCH REDUCED FROM INITIAL ESTIMATED RELEASE RATES. THE CORE IS MOST LIKELY STILL SMOLDERING.
- EVACUATION WAS OUT TO 18 MILES.

- LIVESTOCK WERE SLAUGHTERED OUT TO 12 MILES.
- 49,000 PEOPLE WERE EVACUATED APPROXIMATELY 60 MILES TO THE SOUTH.
- UNITS 1, 2, AND 3 ARE REPORTED MANNED AND BEING COOLED.

WE DO NOT YET HAVE ANY AUTHORITATIVE DESCRIPTION OF THE CHERNOBYL ACCIDENT. THE SOVIET GOVERNMENT HAS ONLY STATED THAT THE MOST PROBABLE CAUSE OF THE ACCIDENT WAS A CHEMICAL EXPLOSION IN THE REACTOR.

BASED ON THE INFORMATION AVAILABLE TO DATE, WE CAN CONSTRUCT THE FOLLOWING:

- AT SOMETIME AROUND MIDNIGHT, APRIL 25 OR IN THE EARLY MORNING HOURS OF APRIL 26, 1986, AN EXPLOSION OCCURRED AT THE CHERNOBYL NUCLEAR PLANT, UNIT #4. THE EXPLOSION IS SAID TO HAVE OCCURRED IN THE BUILDING WHICH HOUSES THE REACTOR. AS A RESULT OF THE EXPLOSION, THE ROOF OF THE REACTOR BUILDING CAUGHT FIRE. THERE ARE NO DETAILS, BUT IT APPEARS THAT THIS FIRE ULTIMATELY RESULTED IN THE CORE GRAPHITE FIRE, AND THE RELEASE OF A SUBSTANTIAL FRACTION OF THE RADIOACTIVITY IN THE CORE.

QUESTION 14 (CONTINUED) - 3 -

- WE DO NOT YET KNOW IF THE INITIAL EXPLOSION OCCURRED AS A RESULT OF DAMAGE TO THE REACTOR FROM ANOTHER FAILURE, OR IF THE INITIAL EXPLOSION ORIGINATED EXTERNAL TO THE REACTOR, AND THE ENSUING FIRE CAUSED A LOSS OF THE ABILITY TO CONTROL THE REACTOR. THIS THEN RESULTED IN SUBSTANTIAL DAMAGE TO THE REACTOR CORE AND THE ENSUING GRAPHITE FIRE.

- BASED ON THE PAUCITY OF ACCURATE INFORMATION REGARDING THE EXACT SEQUENCE OF EVENTS DURING THE FIRST SEVERAL WEEKS FOLLOWING THE TMI-2 ACCIDENT, IT IS LIKELY THAT THE SOVIET GOVERNMENT DOES NOT YET HAVE A COMPLETE, VERIFIED, SEQUENCE OF EVENTS.

- WE ARE CONTINUING TO MONITOR INFORMATION RELEASES FROM THE SOVIET UNION IN ORDER TO INCREASE OUR UNDERSTANDING OF THE EVENT. HOWEVER, ANY FURTHER DESCRIPTION OF THE EVENT CAUSE AND SEQUENCE AT THIS TIME IS ONLY SPECULATION.

ON THURSDAY, MAY 8, 1986, THE NRC'S CHERNOBYL INCIDENT TRACKING TEAM BRIEFED THE NRC'S ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) ON THE CHERNOBYL EVENT. WE HAVE ATTACHED OUR BRIEFING MATERIAL WHICH PROVIDES A COMPREHENSIVE SUMMARY OF INFORMATION ON THE SITE, REACTOR, ACCIDENT, AND RADIOLOGICAL CONSEQUENCES.

QUESTION 15. YOUR TESTIMONY DESCRIBES YOUR R AND D IN THE FIELD OF NUCLEAR SAFETY. IS ANY OF THE R AND D SHARED WITH OTHER COUNTRIES? IF SO, WHICH ONES AND TO WHAT EXTENT AND UNDER WHAT CONDITIONS? IS ANY OF THIS TECHNOLOGY AND RESEARCH SHARED WITH THE SOVIET UNION OR WITH THE EAST-BLOC STATES?

ANSWER.

SINCE THE THREE MILE ISLAND ACCIDENT, COUNTRIES OPERATING NUCLEAR POWER PLANTS HAVE BECOME INCREASINGLY AWARE OF THE NEED TO SHARE OPERATIONAL SAFETY DATA AND EXPERIENCE TO HELP PREVENT ACCIDENTS. THE NRC IS COMMITTED, TO THE EXTENT POSSIBLE, TO SHARE WITH OTHER COUNTRIES NUCLEAR SAFETY INFORMATION WHICH MAY HELP PREVENT SERIOUS NUCLEAR ACCIDENTS IN OTHER COUNTRIES. THE NRC HAS OVER 50 BILATERAL COOPERATIVE AGREEMENTS WITH 21 COUNTRIES PLUS THE AMERICAN INSTITUTE IN TAIWAN WHICH SERVE TO ESTABLISH OFFICIAL COMMUNICATION CHANNELS ON REACTOR SAFETY PROBLEMS, SET UP A NETWORK FOR COOPERATION, AND PROVIDE A VEHICLE FOR EXCHANGE OF TECHNICAL INFORMATION AND RESULTS FROM OTHER COUNTRIES' NUCLEAR SAFETY RESEARCH PROGRAMS.

IN PARTICULAR, THE NRC CURRENTLY HAS GENERAL BILATERAL NUCLEAR SAFETY RESEARCH AND INFORMATION EXCHANGE COOPERATION AGREEMENTS

WITH NEARLY ALL COUNTRIES USING U.S. DERIVED REACTOR TECHNOLOGY IN THEIR NUCLEAR POWER PROGRAMS. INCLUDED ARE COUNTRIES IN WESTERN EUROPE PLUS JAPAN, FINLAND, YUGOSLAVIA, KOREA, BRAZIL AND MEXICO AS WELL AS THE AMERICAN INSTITUTE IN TAIWAN. NRC'S COOPERATION WITH THE USSR AND SUCH EASTERN-BLOC COUNTRIES AS BULGARIA, HUNGARY, CZECHOSLOVAKIA AND POLAND HAS BEEN CONFINED TO IAEA-SPONSORED, MULTILATERAL PROGRAMS.

IN THE AREA OF SEVERE ACCIDENTS AND SOURCE TERM RESEARCH, THE NRC EFFORTS ARE SUPPLEMENTED BY INTERNATIONAL PARTICIPATION. THE COUNTRIES AND ORGANIZATIONS PARTICIPATING IN THIS PROGRAM ARE: THE UNITED KINGDOM, BELGIUM, CANADA, FINLAND, FEDERAL REPUBLIC OF GERMANY, ITALY, JAPAN, KOREA, NETHERLANDS, SPAIN, SWEDEN, AND THE AMERICAN INSTITUTE IN TAIWAN.

IN THE AREA OF THERMAL HYDRAULIC TRANSIENT ANALYSIS, THE NRC PROGRAM INCLUDES CODE ASSESSMENT WORK TO BE DONE BY RESEARCH GROUPS AROUND THE WORLD INCLUDING THE UNITED KINGDOM, BELGIUM, FINLAND, GERMANY, ITALY, JAPAN, KOREA, THE NETHERLANDS, SPAIN, SWITZERLAND, SWEDEN, AND OTHERS WHO ARE EXPECTED TO JOIN THIS PROJECT.

THE NRC IS PRESENTLY PARTICIPATING IN THE CONTINUATION OF THE LOSS-OF-FLUID TEST (LOFT) PROGRAM SPONSORED BY AN INTERNATIONAL CONSORTIUM OPERATED BY THE ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT'S (OECD) NUCLEAR ENERGY AGENCY. THIS CONSORTIUM WAS ORGANIZED TO CONTINUE THE NRC LOFT PROGRAM WHICH WAS ALSO SUPPORTED FINANCIALLY BY AUSTRIA, GERMANY, JAPAN, NORWAY, SWEDEN, THE NETHERLANDS, AND SWITZERLAND.

NUCLEAR SAFETY CONSIDERATIONS ARE BEING ADDRESSED BY COUNTRIES INDIVIDUALLY AND THROUGH PARTICIPATION IN INTERNATIONAL ORGANIZATIONS SUCH AS THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA). THE USSR AND EASTERN-BLOC STATES ARE MEMBERS OF THE IAEA. THE ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT'S NUCLEAR ENERGY AGENCY (NEA) WHICH INCLUDES THE U.S. AND JAPAN IS ANOTHER MAJOR INTERNATIONAL ORGANIZATION DEALING WITH NUCLEAR REACTOR SAFETY. THE NRC WORKS WITH THESE ORGANIZATIONS IN THEIR ACTIVITIES DESIGNED TO IMPROVE NUCLEAR SAFETY STANDARDS AND INTERNATIONAL NUCLEAR EMERGENCY PLANNING AND PREPAREDNESS. IN PARTICULAR NEA MEMBER NATIONS ACCOUNT FOR APPROXIMATELY 240 (77 PERCENT) OF THE 300+ PLANTS CURRENTLY IN OPERATION WORLDWIDE. NEA DEVOTES A MAJOR PORTION OF ITS RESOURCES TO NUCLEAR SAFETY AND REGULATION.

QUESTION 15. (CONTINUED) - 4 -

NUCLEAR SAFETY RESEARCH INTERACTION WITH THE USSR AND EAST-BLOC STATES IS MAINLY THROUGH OUR PARTICIPATION IN IAEA SPONSORED ACTIVITIES. IN 1978 THE NRC WAS NEGOTIATING A BILATERAL PROTOCOL WITH THE USSR FOR THE EXCHANGE OF NUCLEAR SAFETY AND REGULATORY INFORMATION AND COOPERATION IN NUCLEAR SAFETY RESEARCH UNDER THE US-USSR COOPERATION ON PEACEFUL USES OF ATOMIC ENERGY. THESE EFFORTS WERE POSTPONED AS PART OF THE U.S. GOVERNMENT'S PROTEST OF THE USSR ADVANCE INTO AFGHANISTAN. RECENTLY, ACTIVITIES TO REACTIVATE CONTACTS IN THE AREA OF NUCLEAR SAFETY HAVE BEEN UNDERTAKEN.

ALTHOUGH THE ULTIMATE RESPONSIBILITY FOR NUCLEAR SAFETY RESTS WITH THE AUTHORITIES THAT OPERATE NUCLEAR REACTORS IN FOREIGN COUNTRIES, EXCHANGE OF FOREIGN SAFETY INFORMATION ASSURES THAT EVERY COUNTRY USING U.S. TECHNOLOGY CAN HAVE ACCESS TO U.S. NUCLEAR SAFETY EXPERTISE IN CASE OF AN EMERGENCY.

QUESTION 16. I KNOW THAT THE NRC HAS PROGRAMS TO TRAIN FOREIGN TECHNICIANS IN NUCLEAR SAFETY TECHNIQUES. HOW IS THAT PROGRAM FUNDED? HOW MUCH MONEY IS SPENT YEARLY ON IT? WHICH COUNTRIES ARE INVOLVED?

ANSWER.

THERE ARE TWO ASPECTS TO THE NRC TRAINING OF FOREIGN TECHNICIANS, RESEARCH TRAINING, AND REGULATORY TRAINING. RESEARCH TRAINING IS CONDUCTED THROUGH VARIOUS BILATERAL AND MULTILATERAL AGREEMENTS IN WHICH FOREIGN RESEARCH PERSONNEL ARE ASSIGNED TO DOE NATIONAL LABORATORIES WITH NO DIRECT COST TO THE U.S. INDIRECT COSTS FOR THINGS SUCH AS OFFICE SPACE AND ADMINISTRATIVE SUPPORT ARE PROVIDED BY THE U.S. THE FOREIGN RESEARCHERS WORK DIRECTLY ON U.S. RESEARCH PROJECTS AT THE LABORATORIES. THIS PROVIDES THEM WITH TRAINING IN THE USE OF EQUIPMENT OR TRAINING IN THE APPLICATION OF ANALYTICAL TECHNIQUES DEVELOPED BY NRC SCIENTIFIC PERSONNEL. THE U.S. RECEIVES THE BENEFIT OF HAVING ADDITIONAL PERSONNEL ON THE PROJECTS, AS WELL AS THE BROADER PERSPECTIVES MADE POSSIBLE BY INCLUDING PEOPLE FAMILIAR WITH REACTOR TECHNOLOGY, OPERATIONS AND RESEARCH PROGRAMS IN OTHER COUNTRIES. THESE AGREEMENTS OFTEN INCLUDE A PROVISION FOR THE U.S. TO RECEIVE DATA FROM THE FOREIGN NATIONS THAT IMPROVES OUR UNDERSTANDING OF REACTOR BEHAVIOR UNDER A VARIETY OF CONDITIONS. THE NRC CURRENTLY HAS FOREIGN PERSONNEL FROM KOREA, SPAIN, THE NETHERLANDS, UNITED

QUESTION 16. (CONTINUED) - 2 -

KINGDOM, FEDERAL REPUBLIC OF GERMANY AND JAPAN WORKING IN DOE LABORATORIES.

REGULATORY TRAINING IS CONDUCTED AS PART OF AN ON-GOING PROGRAM OF SAFETY COOPERATION WITH OTHER COUNTRIES. IN THIS PROGRAM, FOREIGN REGULATORY AND SAFETY PERSONNEL ARE PLACED IN ON-THE-JOB TRAINING ASSIGNMENTS WITH THE NRC STAFF. NRC ALSO PLACES FOREIGN SAFETY PERSONNEL IN SOME OF ITS FORMAL TRAINING COURSES AT THE TECHNICAL TRAINING CENTER AT CHATTANOOGA, TENNESSEE, ON A SPACE-AVAILABLE BASIS AND, ON OCCASION, SENDS LECTURERS OVERSEAS TO GIVE SUCH COURSES FOR FOREIGN GROUPS. DIRECT COSTS OF THESE EFFORTS, INCLUDING TRAVEL AND SUBSISTENCE EXPENSES OF THE FOREIGN PARTICIPANTS, ARE PAID BY EITHER THE IAEA OR THE BENEFITING FOREIGN ORGANIZATIONS. INDIRECT COSTS ABSORBED BY THE NRC INCLUDE THE USE OF DEDICATED CLASSROOM SPACE, SUPERVISION, LECTURE TIME, AND GENERAL ADMINISTRATIVE SUPPORT. THOSE COUNTRIES AND AREAS WHICH HAVE BEEN INVOLVED IN THIS TRAINING ARE: BRAZIL, CHINA, CZECHOSLOVAKIA, DENMARK, EGYPT, FINLAND, FRANCE, FEDERAL REPUBLIC OF GERMANY, ISRAEL, ITALY, JAPAN, KOREA, MEXICO, THE PHILIPPINES, POLAND, SPAIN, TURKEY, YUGOSLAVIA, AND TAIWAN.

STATUS BRIEFING ON THE CHERNOBYL NUCLEAR ACCIDENT

PRESENTED TO THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

MAY 8, 1986

THEMIS SPEIS, DIRECTOR
BRIAN SHERON, DEPUTY DIRECTOR
DIVISION OF SAFETY REVIEW AND OVERSIGHT
OFFICE OF NUCLEAR REACTOR REGULATION
AND INCIDENT TRACKING TEAM

FRANK CONGEL
JACK KUDRICK

1. DESCRIPTION OF NRC INVOLVEMENT

2. DESCRIPTION OF THE SITE

3A. DESCRIPTION OF THE PLANT

3B. DESCRIPTION OF PRIMARY SYSTEM ENCLOSURE

4. WHAT WE KNOW ABOUT THE ACCIDENT

   A. STATUS OF PLANT AS OF 5/6/86
   B. EVENT
   C. RADIOLOGICAL

5. WHAT ARE FUTURE PLANS

1. DESCRIPTION OF NRC PROGRAM

O PRESIDENT ESTABLISHED INTERAGENCY TASK FORCE

- EPA ADMINISTRATOR LEE THOMAS IS CHAIRMAN OF TASK FORCE
- EPA IS LEAD AGENCY

O HAROLD DENTON IS NRC MEMBER ON INTERAGENCY TASK FORCE

O EDO ESTABLISHED NRC INCIDENT TRACKING TEAM IN NRC

- THEMIS SPEIS IS DIRECTOR, BRIAN SHERON IS DEPUTY DIRECTOR/ALTERNATE

- ORGANIZATION OF TEAM IS SET-UP ALONG LINES OF INCIDENT RESPONSE CENTER ORGANIZATION.

  - PROTECTIVE MEASURES TEAM — ABOUT
  - REACTOR SAFETY TEAM — 20
  - STATUS OFFICER/LIAISON TEAMS — PEOPLE

- TEAM OPERATIONS ARE AT THE INCIDENT RESPONSE CENTER IN MNBB, BETHESDA. TEAM ON DUTY ALL DAY.

O WENT INTO EFFECT MAY 1, 1986

NRC CHERNOBYL TRACKING TEAM

DIRECTOR: DR. THEMIS SPEIS
DEPUTY DIRECTOR: DR. BRIAN SHERON

STATUS OFFICER, DEPUTY AND ASSISTANT: K. PERKINS, R. PRIEBE, J. HIMES
ET SECRETARY: J. RAINES, K. BOHRER, S. JOHNSON

REACTOR SAFETY DIRECTOR: B. SHERON/E. JORDAN

COORDINATOR: J. HICKMAN/D. MARKSBERRY

C. ALLEN	C. KELBER	B. CARTER	J. MILLER
B. HARDIN	M. TOKAR	D. SCALETTI	
W. SWENSON	P. WILLIAMS	C. THOMAS	
J. KUDRICK	F. MIRAGLIA	O. LYNCH	

PROTECTIVE MEASURES: F. CONGEL

COORDINATOR: C. SAKENAS/T. MCKENNA

J. FAIROBENT	W. MEINKE
E. BRANAGAN	R. HOGAN
S. ACHARYA	R. KORNASIEWICZ
J. SWIFT	F. STURZ

LIAISON:

COORDINATOR: B. WEISS/E. WEINSTEIN
IP: R. SENSENEY, H. FAULKNER, J. SHEA, A. GORE, M. MAHY
CIA: W. SWENSEN
PAO: J. FOUCHARD
CAO: S. KENT
FEDS: B. WEISS/E. WEINSTEIN
STATES: D. NUSSBAUMER
NRC REGIONS: R. CAPRA
AEOD: F. HEBDON
NMSS: L. ROUSE/J. LONG

ADP SUPPORT SYSTEMS

COORDINATOR: J. CARTER
J. JULIUS

COMMUNICATIONS COORDINATOR: M. HAWKINS

ADMINISTRATION SUPPORT

COORDINATOR: K. JACKSON/S. SIMONDS

A. STEVENS	M. KING
M. DEBOSE	E. ANTONIOU
E. PEYTON	

2. DESCRIPTION OF THE CHERNOBYL SITE

- THE CHERNOBYL REACTOR SITE IS A 4 UNIT SITE LOCATED ON THE PRIPYAT RIVER APPROXIMATELY 10 MILES NORTHWEST OF CHERNOBYL

- CHERNOBYL IS A SMALL TOWN LOCATED APPROXIMATELY 60 MILES NORTH OF KIEV

- <u>POPULATIONS</u>

  - KIEV - 2½ MILLION
  - PRIPYAT + 3 OTHER NEARBY TOWNS - 49,000
    WITHIN 18 MILE RADIUS (EVACUATION ZONE) - 150,000 TO 180,000
  - WITHIN A 100 MILE RADIUS - 7 MILLION

- TERRAIN APPEARS TO ROLLING HILLS

- ALL FOUR UNITS ARE RBMK-1000 CLASS PLANTS. UNIT 1 OPERATIONAL AROUND 1977, UNIT 4 OPERATIONAL IN 1983. TWO MORE RBMK-1000 CLASS UNITS CURRENTLY UNDER CONSTRUCTION AT SITE.

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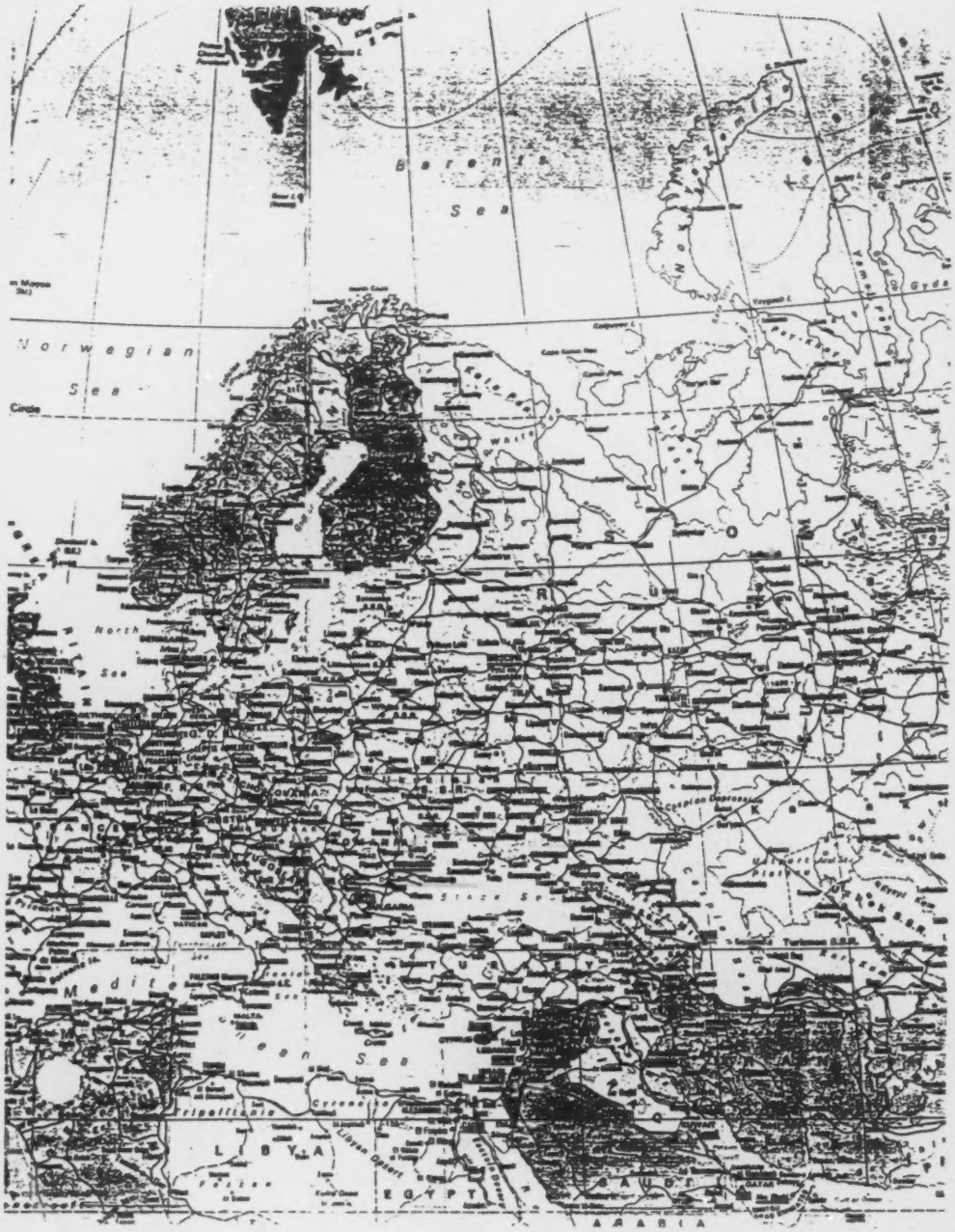
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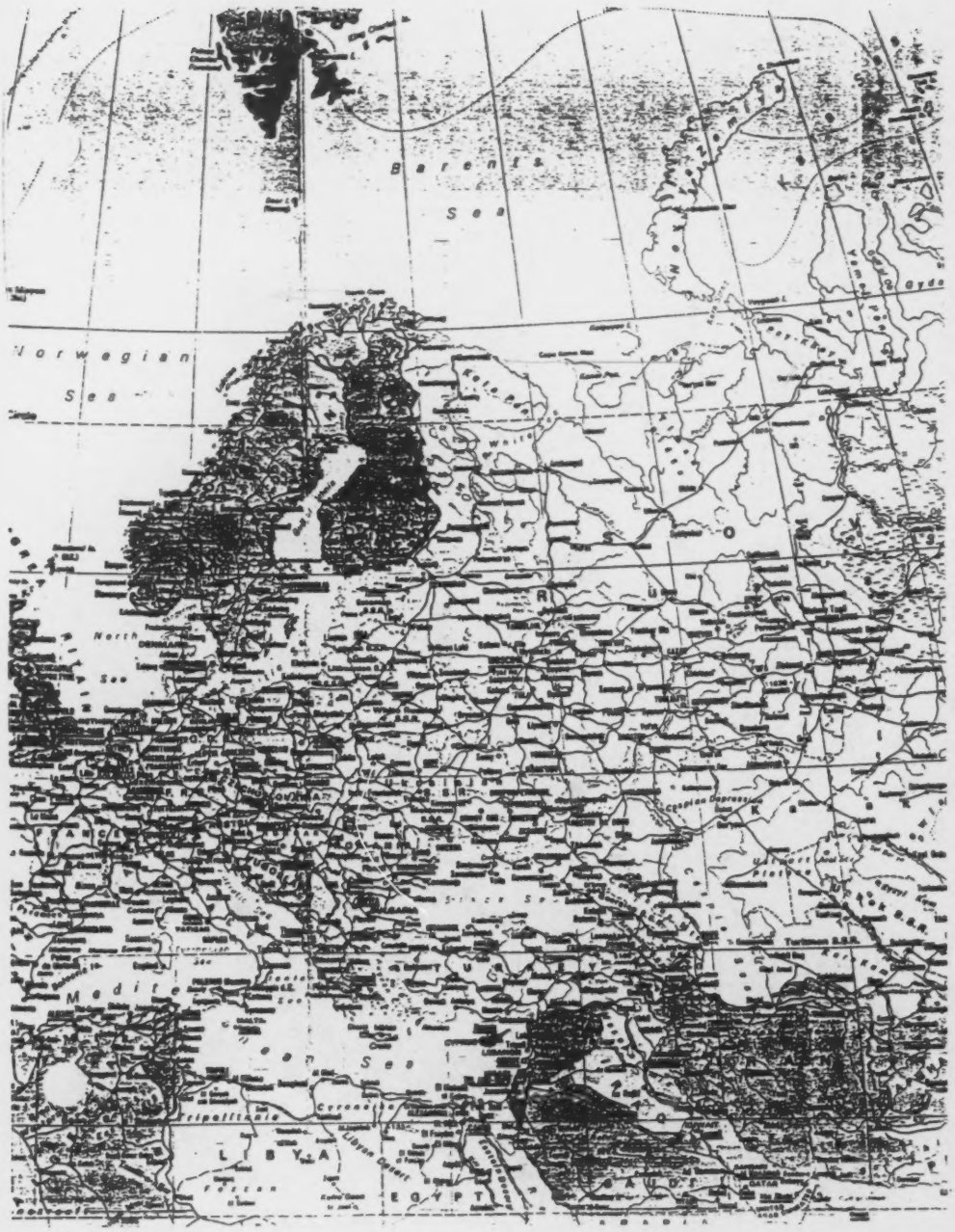
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Black Sea
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Cyrenaica
LIBYA
EGYPT
Libyan Desert
Caspian Depression
U.S.S.R.
SAUDI
ARABIA
QATAR

30'
15'
DNEPR
KIEVSKOYE
VODOKHRANILISHCHE
CHERNOBYL
KIEVSKAYA

3. DESCRIPTION OF THE PLANT

CHERNOBYL PLANT CHARACTERISTICS

- THE CHERNOBYL UNITS (RUSSIAN NAME RBMK-1000) ARE DIRECT CYCLE BOILING-WATER PRESSURE-TUBE REACTORS

- EACH UNIT IS RATED AT ABOUT 3200 MWT

- THE REACTOR FUEL IS CONTAINED IN A LARGE NUMBER (1660) OF INDIVIDUAL ZIRCALOY PRESSURE TUBES IMBEDDED IN A MATRIX OF GRAPHITE BLOCKS.

- EACH PRESSURE TUBE CONTAINS 18 ZIRCALOY CLAD UO_2 FUEL PINS ENRICHED TO ABOUT 1.8% U-235. THE PRESSURE TUBES ARE 8.8 CM (3.5 INCH) IN DIAMETER.

- THE REACTOR IS ABOUT 12M (40 FT) IN DIAMETER AND 8M (26FT) HIGH INCLUDING SIDE AND TOP GRAPHITE REFLECTORS

- THE GRAPHITE MATRIX IS ENCLOSED WITHIN AN INERTED ATMOSHPERE

- SIX OPERATING PUMPS (8 PUMPS TOTAL, TWO PUMPS ARE ON STANDBY) CIRCULATE COOLING WATER TO THE INLET OF EACH INDIVIDUAL PRESSURE TUBE (FUEL ASSEMBLY) THROUGH INDIVIDUAL LINES FOR EACH ASSEMBLY

- STEAM IS PRODUCED WITHIN THE ASSEMBLY AND IS EXTRACTED FROM THE TOP OF EACH PRESSURE TUBE AND COLLECTED IN A HEADER COMMON TO ONE OF FOUR STEAM DRUMS

- CONTROL IS ACCOMPLISHED WITH 211 BORON CARBIDE CONTROL RODS

- THE CONTROL ROD CHANNELS ARE COOLED SEPARATELY

- ON LINE REFUELING (ESSENTIALLY CONTINUOUS)

- EMERGENCY COOLING SYSTEMS ARE DESIGNED FOR MAIN COOLANT PIPE BREAK

- ECCS SYSTEMS INCLUDE

- PASSIVE INJECTION TANKS

- LOW PRESSURE PUMPED INJECTION (ON DIESELS)

- HIGH PRESSURE PUMPED INJECTION (ON DIESELS)

CHERNOBYL PLANT PARAMETERS

GRAPHITE MODERATED BWR (RBMK 1000)	
ON-LINE REFUELING	
REACTOR POWER	3140 MWt
CYLINDRICAL CORE (GRAPHITE MODERATED)	12M DIAMETER 7M HEIGHT
RADIAL GRAPHITE REFLECTOR	1M THICK
TOP AND BOTTOM REFLECTORS	.5M THICK
CORE CONTAINS:	
* URANIUM FUEL ELEMENTS	2% ENRICHED UO2
* MODERATOR	
* COOLANT	
* CONTROL RODS	

CHERNOBYL PLANT PARAMETERS (CONTINUED)

* RADIAL AND VERTICAL NEUTRON FLUX SENSORS

* TEMPERATURE SENSORS

MODERATOR:

* 2488 VERTICAL COLUMNS OF GRAPHITE

* 25CM x 25CM BLOCKS

FUEL ASSEMBLIES: 1700 CELLS

* ENCLOSED IN Zr PRESSURE TUBES 8.8CM DIA.

* 18 FUEL ELEMENTS PER ASSEMBLY EACH 1.35CM DIA.

* ARGON-HELIUM INERTED

CHERNOBYL PLANT PARAMETERS (CONTINUED)

ECCS:

* DESIGNED FOR MAIN COOLANT PIPE BREAK
* PASSIVE INJECTION TANKS
* LOW PRESSURE PUMPED INJECTION (ON DIESELS)
* HIGH PRESSURE PUMPED INJECTION (ON DIESELS)

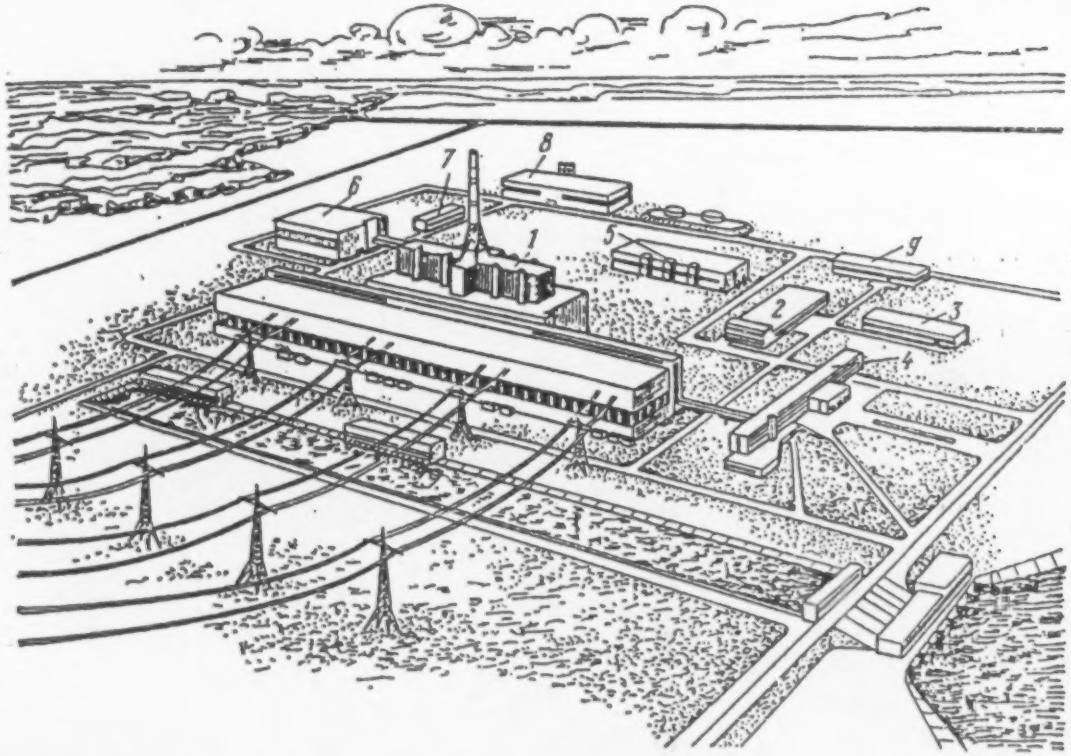
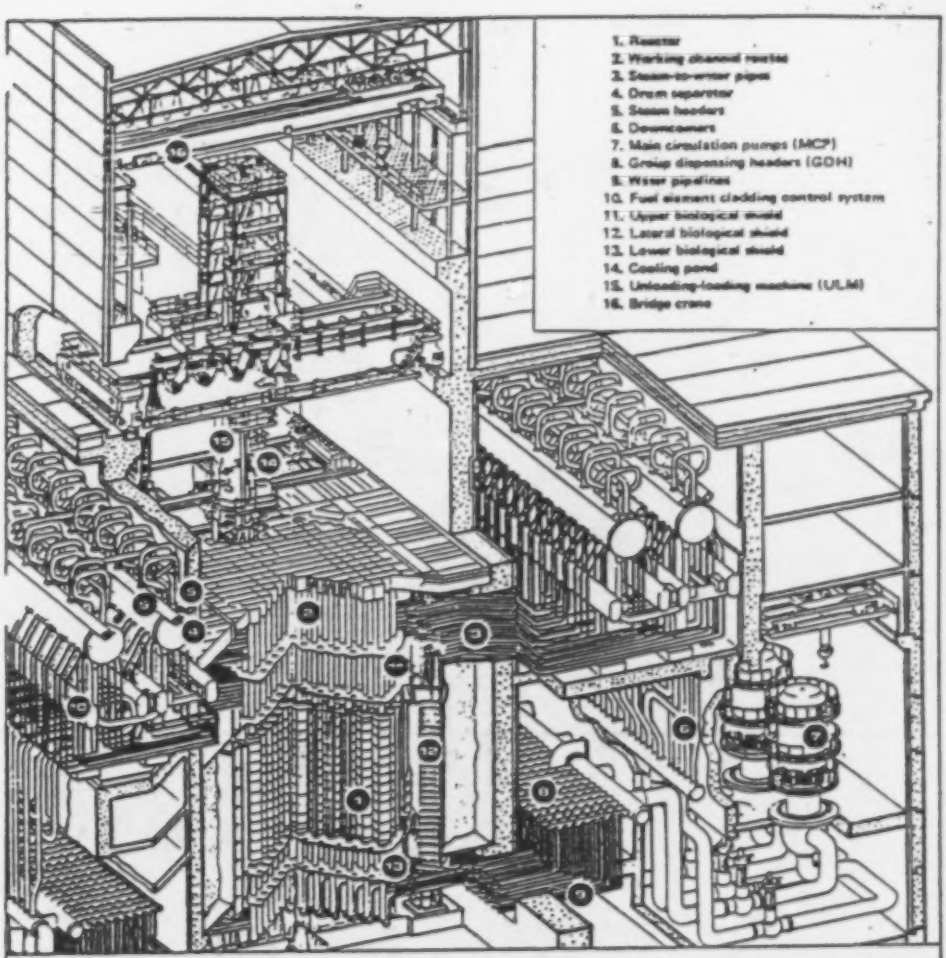


Fig. 3-12. General view of the Smolensk nuclear power plant

1—main building; *2*—auxiliary building and chemical water clean-up building; *3*—chemical storehouse; *4*—administrative and welfare building; *5*—Diesel-generator station; *6*—liquid- and solid-waste storage facility; *7*—nitrogen-oxygen station; *8*—stand-by boiler; *9*—new fuel storage facility



A sectional view of the RBMK-1000 reactor. With an electrical power of 1000 MW, the reactor's thermal power is 3140 MW; the coolant flow is 37.5×10^3 t/h and steam capacity 5.4×10^3 t/h. The reactor inlet water temperature is 270°C and the saturated steam temperature 284°C with a pressure in the separator of 70 kg/cm^2. The initial fuel enrichment is 1.8%.

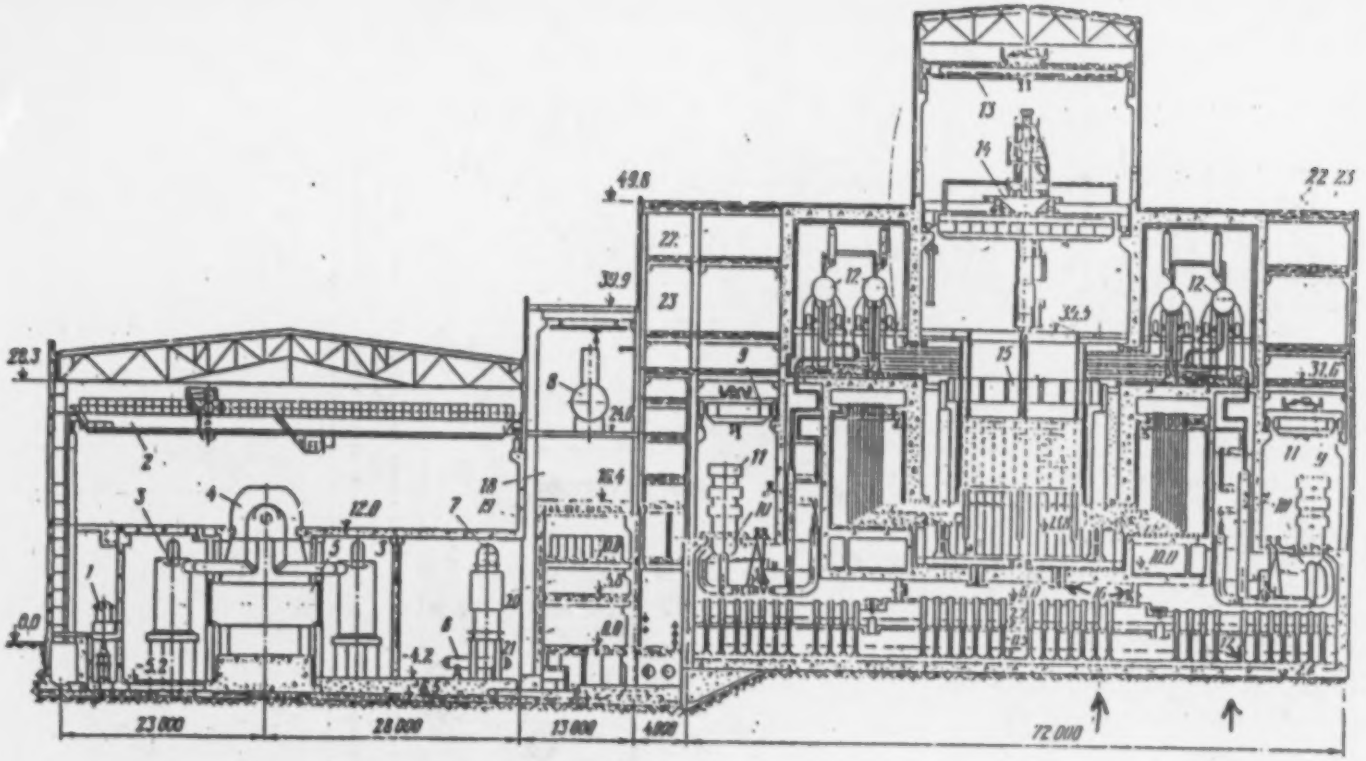
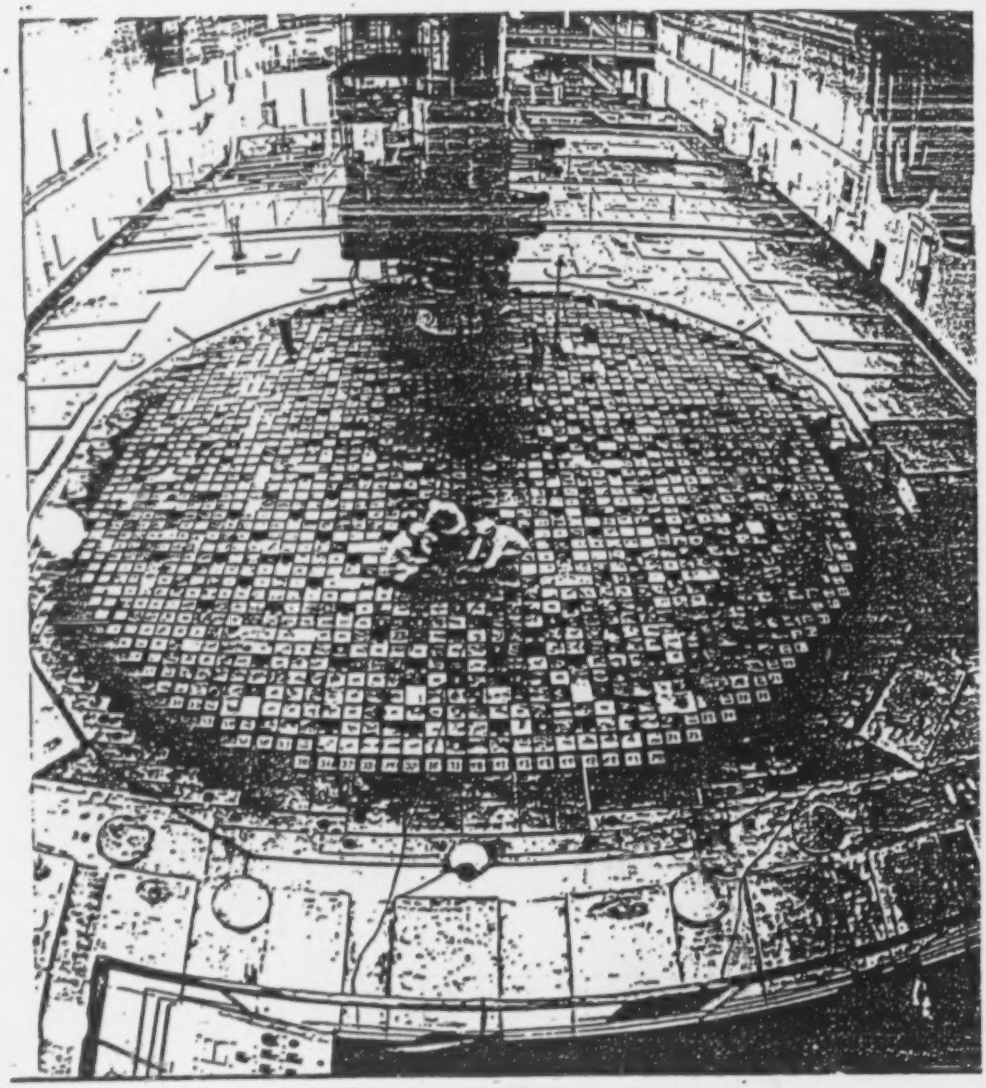
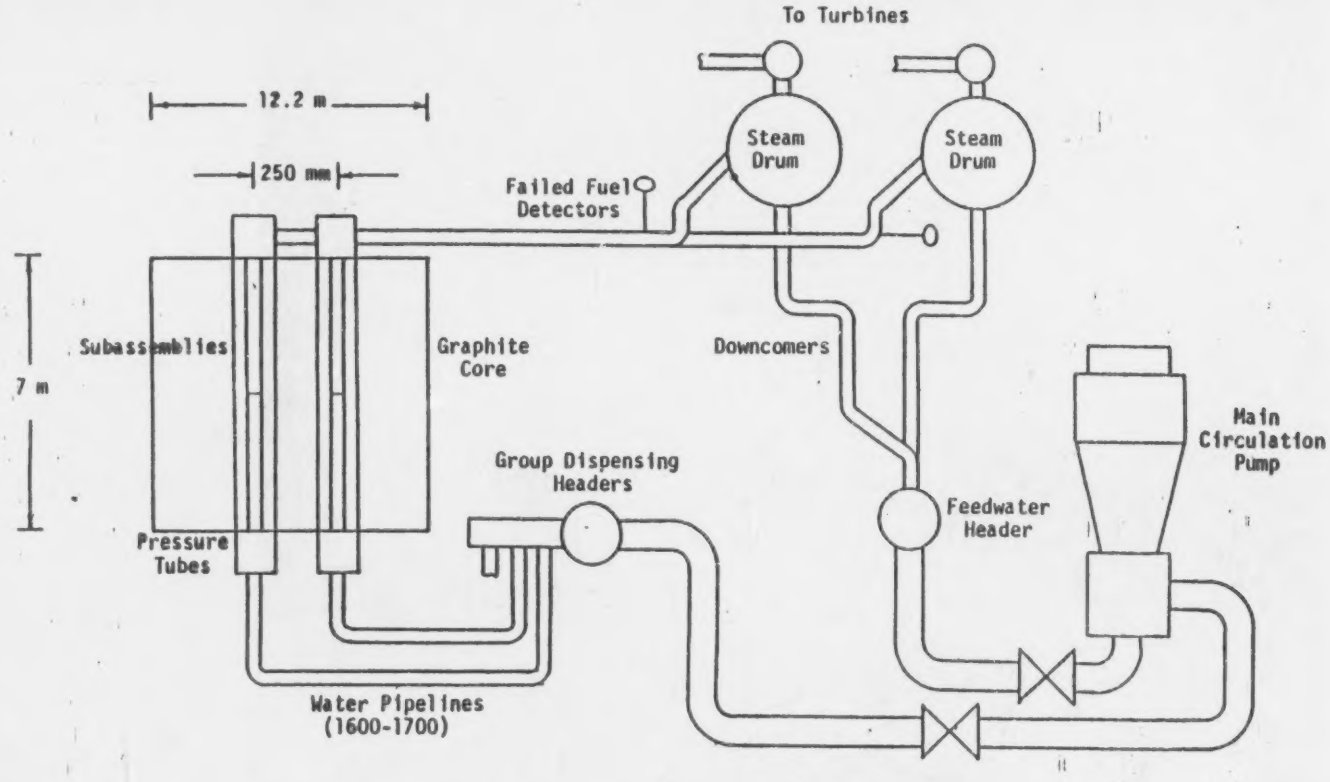


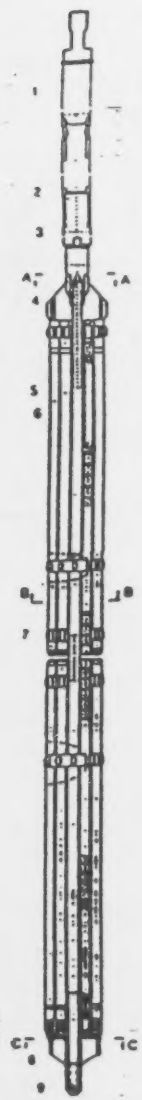
Fig. 3-13. Cross-sectional view of the main building at Smolensk

1—first-stage condensate pump; *2*—125/20-t overhead travelling crane; *3*—separator-steam superheater; *4*—K-500-65/3000 steam turbine; *5*—condenser; *6*—additional cooler; *7*—low-pressure heater; *8*—generator; *9*—50/10-t overhead travelling crane; *10*—main circulating pump; *11*—electric motor of main circulating pump; *12*—drum separator; *13*—50/10-t remotely controlled overhead travelling crane; *14*—refueling mechanism; *15*—RBMK-1000 reactor; *16*—accident containment valves; *17*—bubbler pond; *18*—pipe aisle; *19*—modular control board; *20*—location beneath control board room; *21*—house switchgear locations; *22*—exhaust ventilation plant locations; *23*—plenum ventilation





Schematic of an RBMK-1000 Generating Unit



1 Hanger
2 Pin
3 Transition piece
4 Stem
5 Fuel element
6 Supporting rod
7 Sleeve
8 Nose piece
9 Nuts

RBMK Fuel Assembly

- 1600-1700 pressure tubes
- 1 fuel assembly per pressure tube, 250 mm pitch
- 2 subassemblies per pressure tube, 3.5 m long
- 20 mm gap between subassemblies
- 18 Zirconium clad UO2 fuel rods per subassembly
- 1.8 - 2.0% enriched uranium in fuel rods
- Self-powered detectors mounted in central thimbles of 130 fuel assemblies
- Argon-helium gas mix in gap between clad and pellet
- Coolant fed into channel from the bottom

RBMK Control Rods

- 211 control rods, 700 mm pitch, 45° to the fuel lattice
- Cooling for control rods separate from water pipelines
- Control rods on top and bottom of core
- Made of a boron carbide sleeve inside an aluminum alloy tube

Reactor Core

- Height - 7 m
- Radius - 12.2 m
- Moderator consists of 250 X 250 mm blocks
- Reflector 1 m thick on sides, 0.5 m thick on ends
- Thermocouples at joints of blocks at 3 heights to measure temperature of graphite

3B. DESCRIPTION OF PRIMARY SYSTEM ENCLOSURE

RBMK-1000

ENCLOSURE PHILSOPHY

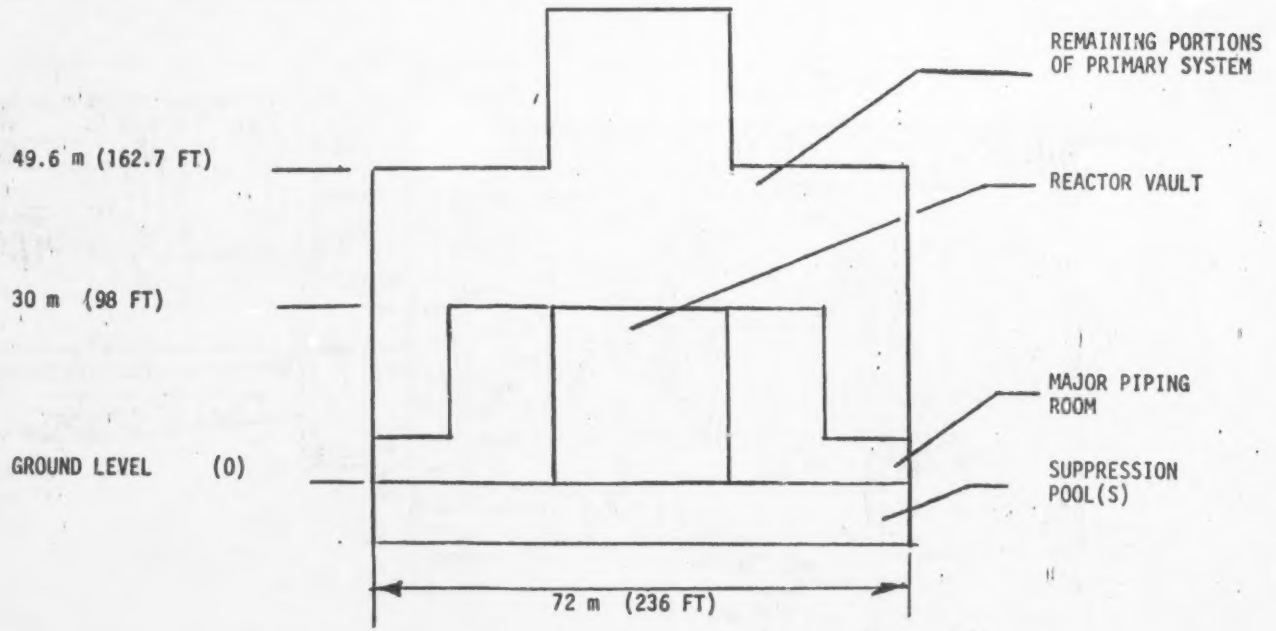
DEDUCED FROM LITERATURE

- ENCLOSE REACTOR AND MAJOR PIPING WITHIN TWO DRY WELLS
- PROVIDES A WETWELL BENEATH THE DRYWELL STRUCTURES
- ENCLOSE REMAINING PRIMARY SYSTEM WITH A CONFINEMENT STRUCTURE
- METAL LINED RECTANGULAR VOLUMES

CURRENT CONCLUSIONS:

- WE DO NOT HAVE ENOUGH INFORMATION TO DRAW ANY DEFINITE CONCLUSIONS REGARDING THE CAPABILITIES OF THE PRIMARY SYSTEM ENCLOSURE
- IT APPEARS THAT THE SOVIET PHILOSOPHY OF CONTAINMENT/ CONFINEMENT MAY BE SIGNIFICANTLY DIFFERENT FROM U.S./EUROPE

PLANT ARRANGEMENT



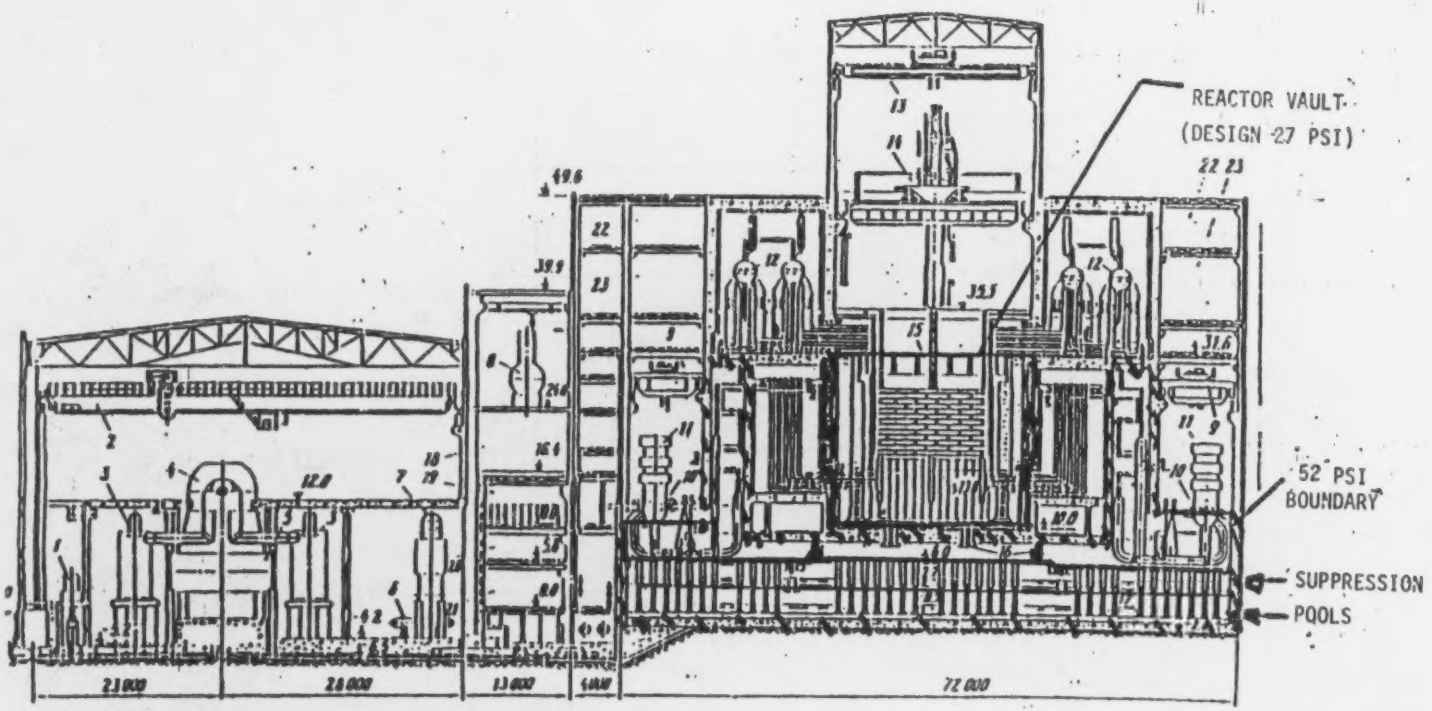


Fig. 2. Cross-sectional view of the main building at Smolensk

1—first-stage condensate pump; *2*—125/20-t overhead travelling crane; *3*—separator-steam superheater; *4*—K-500-65/3000 steam turbine; *5*—condenser; *6*—additional cooler; *7*—low-pressure heater; *8*—deaerator; *9*—50/10-t overhead travelling crane; *10*—main circulating pump; *11*—electric motor of main circulating pump; *12*—drum separator; *13*—80/10-t remotely controlled overhead travelling crane; *14*—refueling mechanism; *15*—PGVM-1000 reactor; *16*—accident containment valves; *17*—bubbler pond; *18*—pipe aisle; *19*—modular control board; *20*—location beneath control board room; *21*—house switchgear locations; *22*—exhaust ventilation plant locations; *23*—plenum ventilation plant locations

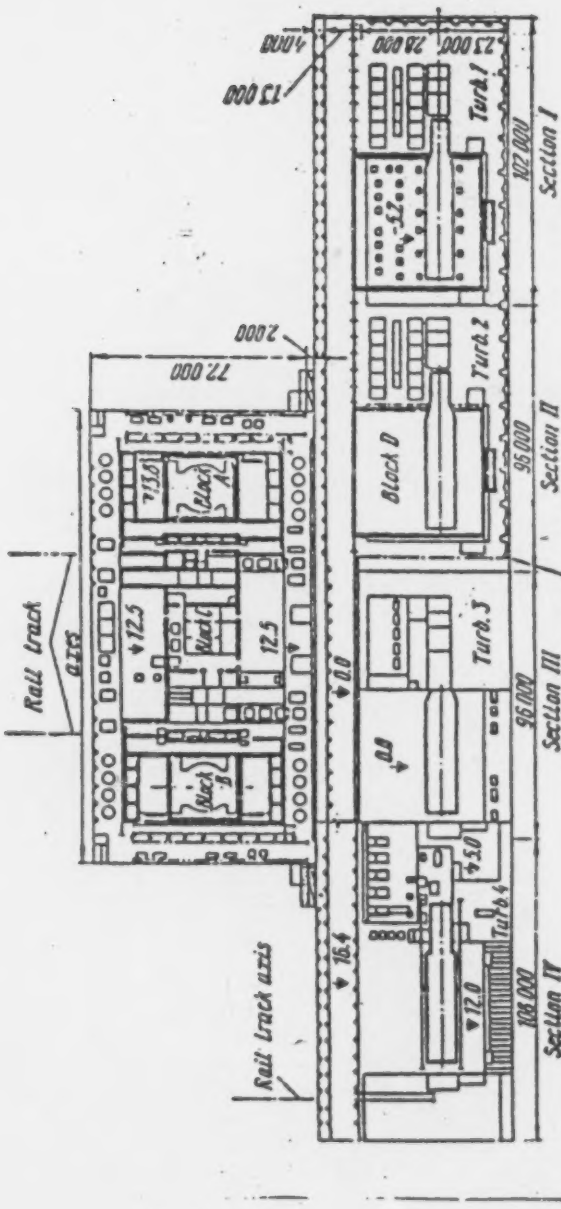


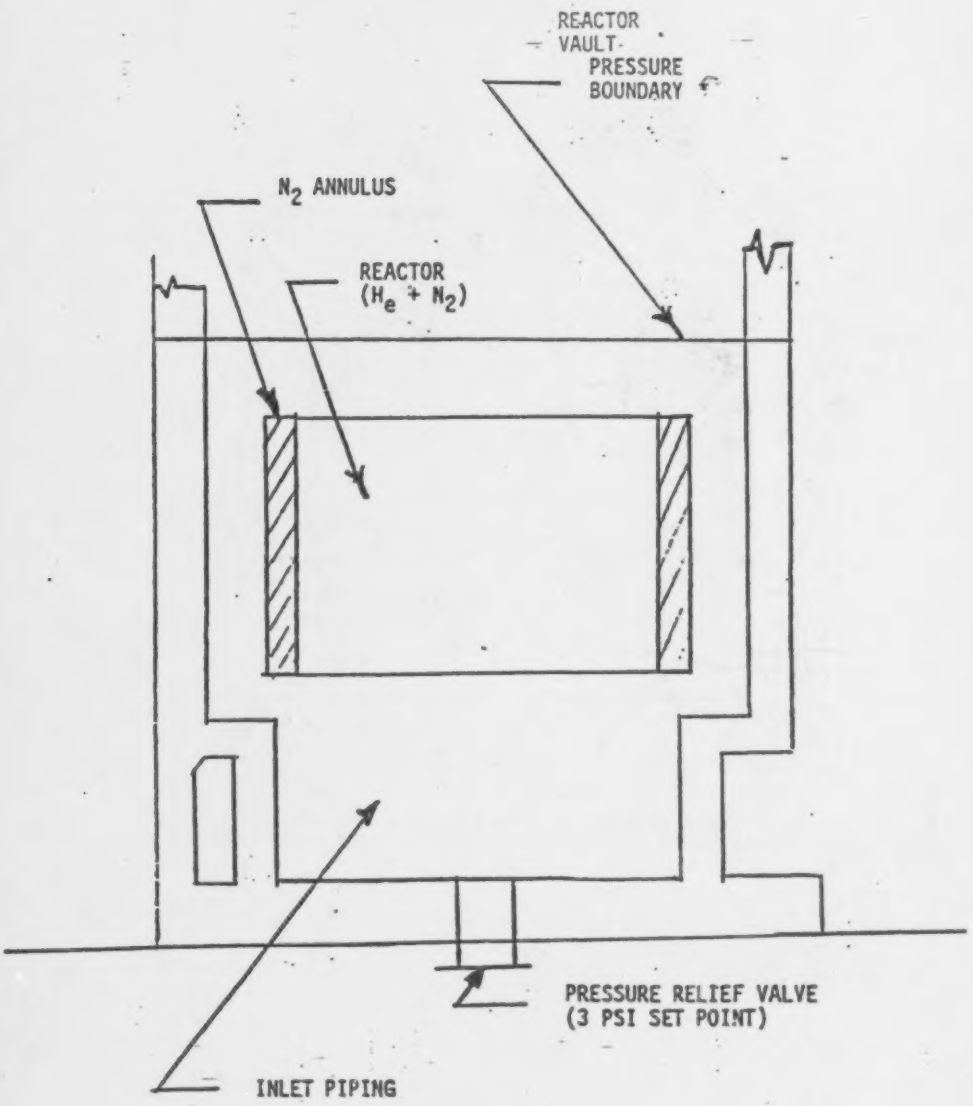
Fig. 3-14. Plan of the main building at Smolensk

REACTOR VAULT

- REACTOR He + N_2 FILLED
- NITROGEN FILLED ANNULUS
- LOWER PIPING AND CONTROL ROD REGION
- DESIGN PRESSURE: .18 MPa (27 psi)
- MAXIMUM PIPE DIAMETER: 88 mm (3.5 in.)
- RELIEF VALVES TO SUPPRESSION POOL(S)
- RELIEF SETPOINT .02 MPa (3 psi)

REACTOR VAULT

DESIGN PRESSURE = .18 MPa (27 PSI)



* REACTOR VAULT ONLY, NOT PRIMARY SYSTEM.

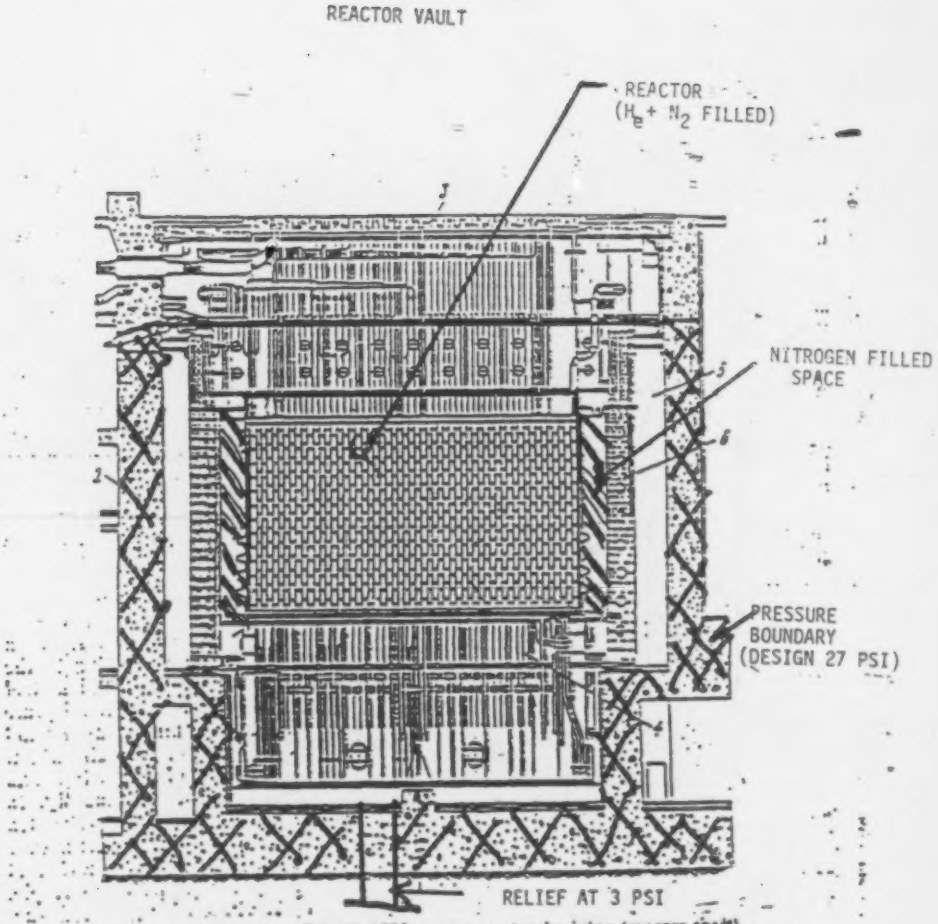


Fig. 3 Cross-sectional view of an RBMK-1000 reactor station building (reactor shaft)
1—steel blocks; 2—ordinary concrete; 3—iron-barium-serpentinite-cement blocks; 4—serpentinite; 5—sand; 6—water

MAJOR PIPING ROOM(S)

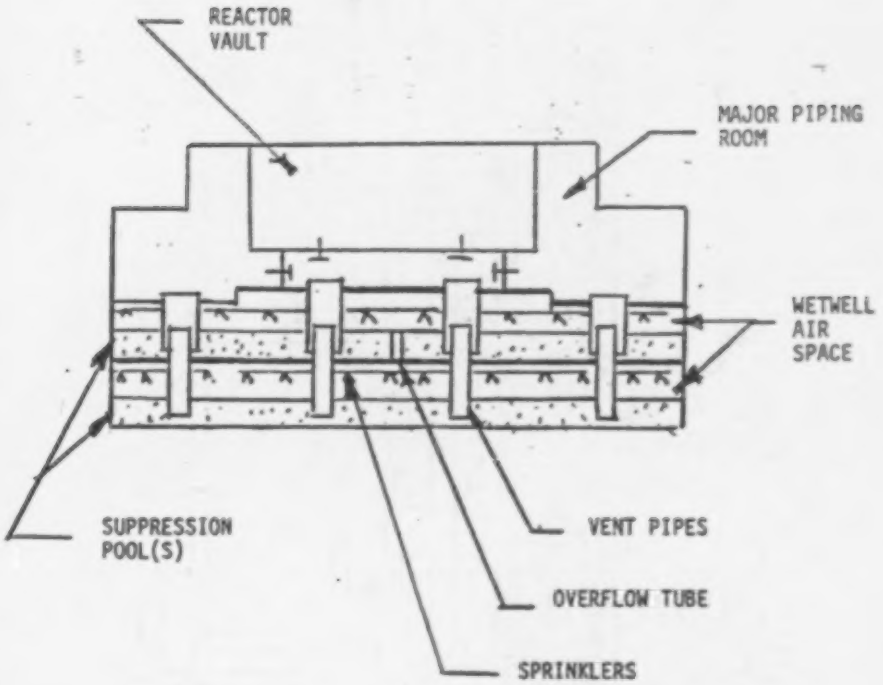
- LOCATED BENEATH REACTOR RECIRCULATING PUMP MOTORS
- CONTAINS MAJOR PIPING
- DESIGN PRESSURE: .35 MPA (52 PSI)
- MAXIMUM PIPE DIAMETER: 900 MM (30 IN)
- RELIEF TO SUPPRESSION POOL VIA VENT PIPES

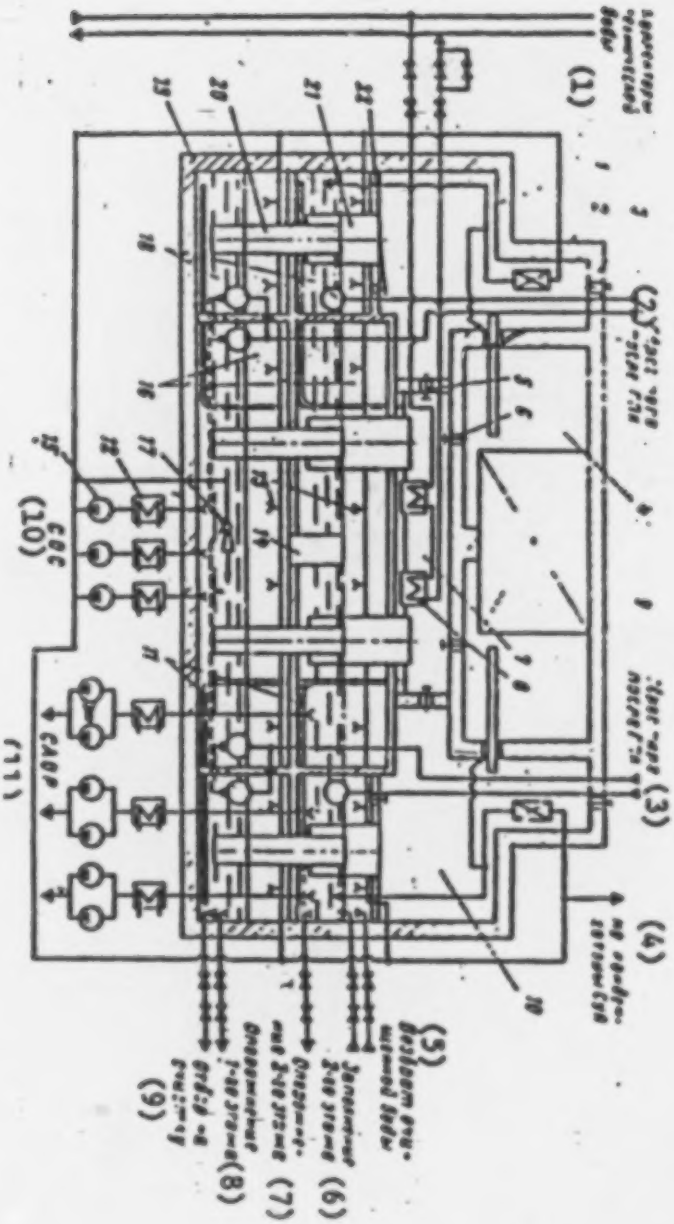
SUPPRESSION POOL

- TWO SUPPRESSION POOLS (ONE ON TOP OF THE OTHER)
- DESIGN PRESSURE: UNKNOWN
- VENT PIPE DIAMETER: 280 MM (11 IN)
  400 MM (16 IN)
- VENT SUBMERGENCE: 3 FT
- OVERHEAD SPRAYS

SUPPRESSION POOL

ARRANGEMENT





ADDITIONAL CONSIDERATIONS

- LEAKTIGHT VOLUMES PERIODICALLY LEAK TESTED
- SRV's ROUTED TO POOL
- POOL(S) USED AS ECCS RECIRCULATION SOURCE
- NON-INERTED VOLUMES

4. WHAT WE KNOW ABOUT THE ACCIDENT

4.A. STATUS OF PLANT AS OF 5/6/86

- UNIT 4 REACTOR BUILDING IS DESTROYED
- SOME RADIOACTIVITY REPORTED TO BE STILL LEAKING FROM PLANT
- SITE EVACUATED OUT TO 18 MILES (150,000 - 180,000?)
- LIVESTOCK SLAUGHTERED WITHIN 12 MILE RADIUS
- CONTROL ROOMS OF INTACT 3 UNITS ARE REPORTED TO BE MANNED
- THREE INTACT UNITS ARE BEING COOLED
- SOME CLEANUP ACTIVITIES REPORTED TO BE UNDERWAY
- EVACUEES TAKEN TO VILLAGES APPROXIMATELY 60 MILES SOUTH OF CHERNOBYL AND WEST OF KIEV

UNITED PRESS INTERNATIONAL/REUTER

Soviet TV showed damaged nuclear plant at Chernobyl. The commentator said it disproved reports of massive damage.

4.B. EVENT SCENARIO (PRELIMINARY)

- AS REPORTED BY SOVIET GOVERNMENT

  - INITIAL CHEMICAL EXPLOSION OCCURRED AS PLANT WAS GOING INTO PLANNED SHUTDOWN

  - TIME OF EXPLOSION WAS 1:23, APRIL 26, 1986

  - BASED ON RADIONUCLIDE MEASUREMENTS, STAFF HAS CALCULATED TIME OF PLANT SHUTDOWN AT ABOUT MIDNIGHT, APRIL 25, 1986

  - THIS IS CONSISTENT WITH SOVIET REPORTS

- WE DO NOT YET HAVE ANY AUTHORITATIVE DESCRIPTION OF THE CHERNOBYL ACCIDENT

64-415 O - 86 - 24

- BASED ON INFORMATION AVAILABLE TO DATE, WE CAN CONSTRUCT THE FOLLOWING:

  - AT 1:23 AM, APRIL 26, 1986 AN EXPLOSION OCCURRED AT THE CHERNOBYL NUCLEAR PLANT, UNIT 4

  - EXPLOSION IS SAID TO HAVE OCCURRED IN THE BUILDING WHICH HOUSES THE REACTOR (SOVIETS CALL THIS THE MACHINE HALL)

  - AS A RESULT OF EXPLOSION, THE ROOF OF THE REACTOR BUILDING CAUGHT FIRE

  - FIRE DAMAGE CAUSED A BREACH OF REACTOR CONTAINMENT

  - INITIAL RADIOACTIVE RELEASE

  - SUBSEQUENT INITIATION OF GRAPHITE FIRE

- o THERE ARE MANY POSSIBLE SCENARIOS FOR CHERNOBYL THAT CAN LEAD TO THE DAMAGED CORE.

- o WE STILL DO NOT KNOW ABOUT THE ACTUAL SEQUENCE OF EVENTS WERE.

SOME POSSIBILITIES ARE:

- EXPLOSION/FIRE IN TURBINE OR REACTOR BUILDING ULTIMATELY CAUSES LOSS OF CONTROL (COOLING) TO CORE. LEADS TO CORE UNCOVERY AND MELTDOWN

- EXPLOSION/FIRE IN TURBINE OR REACTOR BUILDING CAUSES FAILURE OF REACTOR BUILDING AND DAMAGES REACTOR

OTHER POSSIBILITIES:

- FUEL HANDLING ACCIDENT

- FLOW BLOCKAGE

- REACTIVITY TRANSIENT

ROUGH DESCRIPTION OF A HEATUP SCENARIO

- PRIMARY COOLANT WATER BOILS OFF
- WITH REACTOR SHUT DOWN, NO HEAT GENERATION IN GRAPHITE
- FUEL AND GRAPHITE COOL AND APPROACH QUASI-THERMAL EQUILIBRIUM
- FUEL UNCOVERS OVER SEVERAL HOURS AND HEATS UP
- FUEL CLADDING OXIDATION AND FAILURE
- FUEL ASSEMBLY CASING FAILURE NEAR TOP OF CORE
- HIGH PRESSURE-HIGH TEMPERATURE STEAM AND OTHER GASES PRESSURIZE THE GRAPHITE CAVITY
- FAILURE OF GRAPHITE CAVITY ALLOWS AIR INGRESS TO CORE REGION
- GRAPHITE FIRE STARTED AND A CHEMICAL (GAS) EXPLOSION IS POSSIBLE
- GRAPHITE CONTINUES TO BURN OVER A LONG TIME

- IT IS MOST LIKELY THAT THE SOVIETS DO NOT YET KNOW WITH CERTAINTY THE ACTUAL SEQUENCE OF EVENTS.

- THIS IS SIMILAR TO OUR KNOWLEDGE OF THE SEQUENCE OF EVENTS AT TMI-2 WITHIN THE FIRST WEEK OR SO AFTER THE ACCIDENT.

SUBJECTS

SOURCES OF DATA
SUMMARY OF ENVIRONMENTAL DATA
METEOROLOGY
SOURCE TERM
EXTRAPOLATION FACTORS
DOSES
HEALTH IMPLICATIONS

SOURCES OF ENVIRONMENTAL DATA

ELEVATED LEVELS OF RADIOACTIVITY DETECTED IN MORE THAN 10 COUNTRIES

SWEDEN AND FINLAND PROVIDED ACTIVITY MEASUREMENTS AS A FUNCTION OF TIME BEGINNING SHORTLY AFTER THE ACCIDENT

ENVIRONMENTAL DATA: 26–28 APRIL 1986

SWEDEN

I–131 IN AIR: 100 – 10000 pCi/m3
Cs–137 IN AIR: 1 – 1000 pCi/m3
Cs–134 IN AIR: 1 – 1000 pCi/m3
I–131 IN MILK: <700 – 40000 pCi/l
DIRECT RADIATION: 20 – 250 micro R/hr

FINLAND

I–131 IN MILK: 100 – 1000 pCi/l
DIRECT RADIATION: 10 – 100 micro R/hr

ATMOSPHERIC TRANSPORT AND DIFFUSION

METEOROLOGICAL CONDITIONS AT 1500 M APPEAR TO REPRESENT BEST TRANSPORT FOR MAJORITY OF INITIAL RELEASE

WIND SPEED AND DIRECTION AT 1500 M QUITE VARIABLE DURING PERIOD 28 APRIL – 3 MAY –– TRANSPORT OVER NORTHERN, CENTRAL, AND SOUTHERN EUROPE AS WELL AS EASTERN SOVIET UNION

WIND SPEED AND DIRECTION AT 1500 M OFTEN QUITE DIFFERENT FROM NEAR–SURFACE CONDITIONS –– SUGGESTS DE–COUPLING OF AIRFLOW AND CONSIDERABLE VARIATION OF TRANSPORT AND DIFFUSION WITH HEIGHT OF RELEASE

SOURCE TERM

SOURCE TERM ESTIMATED BY EXTRAPOLATION OF ESTIMATED DOSE FROM CONCENTRATION MEASUREMENTS IN FINLAND AND SWEDEN BACK TO CHERNOBYL SITE

ENERGETIC ATMOSPHERIC RELEASE SIMILAR TO WASH–1400 PWR1 AND PWR2 IN MAGNITUDE WITHOUT ACTINIDES (EXCEPT Np–239) –– UNCERTAINTIES DO NOT PRECLUDE RELEASES OF PWR3 MAGNITUDES

RELEASE SCENARIO FOR CHERNOBYL IS PROBABLY DIFFERENT FROM WASH–1400 SCENARIOS

AVAILABLE DATA INDICATE PROLONGED RELEASE

EXTRAPOLATION FACTORS
(BACK TO CHERNOBYL SITE)

ACCOUNT FOR:

- DISPERSAL IN AIR
- RADIOACTIVE DECAY
- CLOUD DEPLETION

VALUES FOR:

- EXPOSURE TO NOBLE GASES (1 E+5)
- INHALATION OF IODINES (1 E+6)

ESTIMATED DOSES

LOCATION	DOSE,* REM WHOLE BODY	THYROID
STOCKHOLM (750 MI)	0.002	0.01
HELSINKI (700 MI)	0.005	NO DATA
CHERNOBYL (1 MI)	>100	4000
CHERNOBYL (20 MI)	>1	40

* BASED ON 1–DAY EXPOSURE IN USSR;
2–DAYS FOR SWEDEN AND FINLAND

HEALTH IMPLICATIONS

SHORT–TERM:

SEVERE PHYSICAL TRAUMA, INCLUDING DEATH WITHIN 1 – 3 MILES

LONG–TERM:

FATAL AND NON–FATAL CANCERS (POTENTIALLY WORLD–WIDE)

GENETIC EFFECTS

Senator Domenici: How much money is DOE contributing to the various military reactor research activities at DOE? When will we see a significant increase in DoD's contributions to these programs?

Answer: Within SDIO, DOE supports reactor research as part of joint programs with two directorates: Directed Energy, and Survivability, Lethality and Key Technologies (SLKT). The main SLKT activity is the Power and Power Conditioning Program, part of which is co-funded under the DOE Assistant Secretary for Nuclear Energy. DOE and DoD funding for the two projects involving reactors are as follows:

		FY 86	FY 87
SP-100 Ground Test	DOE	$16.0M	$30.0M
	SDIO	$15.0M	$50.0M
Multimegawatt Technology	DOE	$ 1.8M	approx $22M
	SDIO	$14.0M	approx $26M

The FY 87 budget requests for Multimegawatt are approximate because these funds are part of larger activities. The SDIO request in FY 87 for Multimegawatt is $52.4M including both nuclear and non-nuclear power system concepts; $26M is the approximate amount to be used for the nuclear portion. The exact division of funds depends on the results of ongoing assessment studies of the various concepts.

Senator Domenici: When will DoD be in a better position to commit to some of the DOE reactor research activities that are now in the conceptual stage? Can you give some specifics?

Answer: In terms of multimegawatt power systems for SDIO space-based platforms, the trade studies and assessments of various options are in the early stages. The Multimegawatt Technology Program was an FY 86 start, and we have relied heavily on power system concepts generated by the DOE laboratories in order to obtain a quick grasp of the issues, problem areas, and potential solutions to generating large amounts of power in the space environment. Although the power levels required to fire electrically-driven kinetic and directed energy weapons are very high, run times are short enough to accommodate non-nuclear approaches as well. Plans are to select a few multimegawatt concepts in FY 88 for more detailed study, and one or more nuclear concepts will be included. One thing that is clear even at this early stage is that the power system options must be assessed in the context of the overall platform trades, and nuclear systems offer solutions to some of the perceived problems. For example, the detrimental effects of effluents from the power system can be minimized with reactor systems which are closed cycle or have relatively benign exhaust products.

Senator Domenici: Does the DoD have a clear enough idea as to its specific performance requirements with respect to each of the military reactor concepts to be able to provide clear focal points to DOE's military reactor development programs?

Answer: The answer depends on the program and its intended applications. SP-100 is a power system technology program to fulfill the needs of several potential space missions for not only SDIO, but other military branches and NASA. Although power levels and duty cycles for these applications vary and are not finalized, other requirements (such as lifetime, reliability, survivability) are clear enough to proceed. Equally important is the fact that the technology and components are readily adaptable to a wide range of power requirements.

The multimegawatt power requirements for SDIO are not defined in detail at this stage. What is clear is that the power and voltage levels required are orders of magnitude greater than our experience and technology base for spacecraft. Consequently, both the nuclear and non-nuclear portions of the Multimegawatt Technology Program are structured to develop the necessary conceptual design and critical component technology so that the correct decisions are made as to which power systems should be pursued if the decision to deploy a strategic missile defense is made. Power system considerations are one of a multitude of factors influencing the SDIO architecture, and the evolving architecture drives the power system needs. Consequently, the DOE multimegawatt space nuclear technology effort stresses research and technology base development rather than design and fabrication of reactors to meet specific performance requirements.

QUESTIONS ON THE MULTI-MEGAWATT TERRESTRIAL POWER (MTP) PROGRAM

1. What are the Air Force requirements for MTP?

We have strong and increasing requirements for secure energy for mission-essential operations. The complexity of the Air Force mission has grown over the years, and energy is now more important than ever in our ability to maintain peacetime training, readiness, and credible deterrence; to provide for quality of life and workplace; and to perform and sustain wartime operations. The integral importance of energy to weapons and weapon support systems is expected to increase as the Air Force continues to modernize. At the same time, the key components of our national and international energy supply, generation, and distribution systems remain vulnerable to accident, natural disaster, terrorism, sabotage, war, and hostile political-economic actions. We are also concerned about adverse trends in national energy supply reported by Government and industry authorities in forums such as the July, 1985 Senate Energy and Natural Resources Committee hearings entitled "When Will the Lights Go Out?"

In 1982, we asked DOE to review our needs ahd concerns. In 1983 DOE recommended that we consider small nuclear power systems. In 1984, we signed an agreement with DOE which partitions responsibilities and agrees to share costs in a program for standard design of a 10-Megawatt system. DOE procured from industry design concepts according to our requirements, and we reviewed them comprehensively. Based on the positive results of our review, we notified DOE in late 1985 of our strong desire to proceed to design.

2. What are the Air Force plans for FY 86 and FY 87?

We will work with DOE to select one of the six competing design concepts and create a standard design. The design will be by industry through DOE procurement. We have agreed to co-support this work with $3M in FY 86 and $5M from our proposed FY87 program and presently are awaiting DOE FY 86 matching funds authorization to their program focal point, the Idaho Operations Office. During these two years, we will also conduct work in support areas of concern to us.

3. What are the alternatives to nuclear power that are being considered?

The overall objective of our energy security program is to ensure that energy is as survivable and sustainable as the mission and mission assets it supports. We are seeking least-cost ways to meet this need. Generation of mission-essential energy is one the options, and we look at nuclear as one means of generation. In our review of design concepts, we evaluated costs closely and found that a generic plant acquired at estimated "production" cost could give us a cost advantage over commercially supplied power. We also found a life cycle present value cost advantage of about $170M over a generally similar diesel plant providing base load mission-essential power at a typical base.

4. Is the program going well so far? Please identify any problems to date that could jeopardize the success of the program.

We are pleased with the response of industry in creating viable design concepts according to very challenging criteria and requirements, particularly in areas where there have been industry issues, such as standardization, modular design, simplicity, passive safety, and generic safety analysis. We are equally pleased with the support we have received from DOE field organizations in this work.

We are depending on DOE for leadership, partnership, and support in the MTP program. Continued Subcommittee support to ensure adequate DOE funding and a responsive DOE program is essential to the success of this program.

Senator Wallop: What is the potential impact of nuclear fusion energy R&D upon SDI systems? If it is true that in a space-based nuclear power system, the problem of exhaust from the generation of power is a key environmental problem, wouldn't the application of fusion energy power generation help to solve that problem, since it generates so little waste, or such a different kind of waste in much lower proportions?

Answer: At this time, the potential benefits of applying fusion energy to SDI systems are unclear. For all open cycle power systems, both nuclear and non-nuclear, the effect of exhaust products on operation of the several subsystems that make up the platform is a key question. This issue and several others are being addressed as part of SDI power system architecture contracts to be awarded this month. One of the key characteristics of electrically-driven kinetic and directed energy weapons is the large quantity of liquid hydrogen used as a coolant. After cooling the weapon, this same hydrogen can be used as a fuel or working fluid for some of the power system options under consideration. Hence, effluents of hydrogen or hydrogen compounds are part of these studies. If effluents are detrimental, closed cycle approaches may be needed. Since it has not been determined what types or quantities of effluent can be tolerated, the merits of fusion energy cannot be judged as yet. If fusion is desirable, it will have to be considered as one of the longer term options for SDI space power.

Senator Wallop: Can we assume that the Soviet Union, in its SDI R&D program, is also grappling with this technical problem for nuclear power generation and waste disposal in space? Wouldn't that be a key reason for their desire to have us cooperate with them in a joint fusion energy research program?

Answer: The Soviets have been using low-power reactor systems in space for some time, and it appears fair to assume that they are exploring larger size power systems as well. To what degree nuclear fusion is under consideration as an option is not known. The potential benefits to ground-based commercial power generation of the successful development of nuclear fusion are more than adequate to warrant Soviet interest. It is doubtful that space-based fusion energy is a key consideration in the Soviet desire for a joint program.

QUESTION: Would a space-based nuclear reactor capable of bursts of power of several hundred megawatts have about the same amount of fissionable material as a commercial reactor of equivalent power capacity?

ANSWER: The amount of fissionable material required for a reactor depends on both the power level and the time of operation. Since multimegawatt burst reactors would have relatively short run times, less fissionable material is needed. As a rough approximation, light water commerical reactors generate about 0.5 to 1.0 megawatts of electricity per kilogram of U-235. Space-based burst reactors would generate about 2.0 megawatts of electricity per kilogram of U-235, so only about one-fourth to one-half as much U-235 inventory would be needed.

QUESTION: What safety precautions would we likely take in launching and assembling a space reactor sized to generate hundreds of megawatts of power?

ANSWER: Although the multimegawatt program is in an early stage, it appears that the safety guidelines being used for the SP-100 program may suffice if reactors are needed for higher power levels. In terms of launch safety, two overriding tenents would be employed. First, the reactor would not be operated prior to or during launch, so no radioactive fission products would be generated in the core before the system had been deployed in a stable orbit. Second, the reactor would be designed to remain subcritical under all credible accident conditions. For the launch sequence, such accidents include severe fire, compaction, projectile, impact, overpressure, and immersion/flooding environments. It is very unlikely that multimegawatt reactor cores would have to be assembled in space; if necessary, heat rejection or storage subsystems might have to be launched separately and integrated with the reactor and power conversion subsystems. If such on-orbit assembly was necessary, and if astronauts performed these tasks, the reactor would most likely be kept in a shutdown mode until assembly was complete and all personnel were at a safe distance.

QUESTION: Please describe in detail the radiation hazards which might result if a rocket suffered a catastropic failure in attempting to launch a multi-hundred megawatt space reactor (or major component thereof) to orbit.

ANSWER: Because no radioactive fission products are present in the core prior to achieving orbit, neither catastrophic failure of the launch vehicle nor failure to reach stable orbit would result in an external radiation hazard. The only remaining issue is the effect of the uranium fuel itself, which depends in enrichment level and the amount of various uranium isotopes (U-234 in particular) that results from the enrichment process. Uranium has a chemical toxicity similar to lead. In addition, inhalation of very small particles (less than 5 microns diameter) could result in internal radiological doses. Preliminary estimates indicate that both air concentration levels and radiation doses would be well below toxicity and radiological limits even under very conservative assumptions. Although the uranium fuel does not appear to be cause for concern, it is one of the issues that will continue to be examined as the multimegawatt safety effort proceeds.

Question: What systems other than SDI would require power levels over 1MW? The burst mode for star wars beam weapons might require hundreds of megawatts according to Col Hess's testimony. Isn't star wars the real driver in the need for large reactors in space?

Answer: One of the most important enabling technologies for future Air Force endeavors in space, is increased power. Nuclear reactor technology appears to offer a solution. High power levels become increasingly important when you consider the potential of the Strategic Defense Initiative (SDI) research. Although the only potential systems envisioned that will require power in excess of 1MW are covered under the SDI umbrella, such research has direct bearing on the current Air Force Space Defense Mission where power levels in the hundreds of kilowatts are anticipated.

QUESTION: A study released recently by the French Ministry of Defense concludes that a defense like SDI could be penetrated and perhaps defeated by even a medium power like France through a number of technological steps. The Delpech study, led by Jean-Francois Delpech, director of France's National Scientific Research Center, found that a space defense system would itself be vulnerable both to an adversary system and ground-launched ASAT systems. The Delpech study further asserted that even "a medium power like France could probably acquire the means to partially neutralize a space defense system, or at least to degread its performance sufficiently to ensure the penetration of its own ballistic missiles." If this is what France believes it could do, couldn't the Soviet Union, with about 20 times as many missiles and 50 times as many warheads as France and a far larger military R&D budget, counter SDI even more effectively?

ANSWER: We have not had an opportunity to review the French report. However, to date our studies have not found such conclusions to be warranted.

QUESTION: In percentage terms, the fastest-growing part of the Soviet strategic nuclear threat is in bombers and cruise missiles, threats which SDI does not deal with at all. The CIA has estimated that by the early 1990's the Soviets will have 2-3,000 cruise missiles in its inventroy. Since SDI does not address either the bomber or cruise missile threat, isn't it incorrect, or at least imprecise, for the Administration to claim that SDI will render nuclear weapons "impotent and obsolete".

ANSWER: No, while it is objective of the SDI to determine the feasiblity of defense against ballistic missile, the technologies which will be applicable to defending against ballistic missiles are also applicable against other threats such as cruise missiles. Other agencies within the Defense Department are tasked with addressing the specific threat posed by cruise missiles.

QUESTION: Michael May, associate director at large at Lawrence Livernmore National Laboratory, has written in Science magazine that "powerful but presently or soon to be available laser systems.... could damage a satellite from 100 to 1000 kilometers away. Satellites in relatively low orbits could be damaged by such systems based on the ground." In view of this, as well as the considerable anti-satellite capability inherent in any SDI system, wouldn't it be extremely difficult to assure the survivability of any space-based SDI component? How could we thus have any confidence in the shielding ability of any SDI system which uses space-based components?

ANSWER: (U) The question of survivability of space based components of the Strategic Defense Initiative must be addressed at the system or architectural level. Unhardened satellites, like today's space systems, could be destroyed by powerful ground based lasers. However, there are a number of concepts being pursued by the SDI that hold the promise of providing the necessary level of system survivability for any future strategic defenses.

(U) The net result is that when looked at from a system perspective, there are several techniques available to the Strategic Defense planner to achieve acceptable system level survivability against very powerful ground based lasers used as ASAT weapons.

APPENDIX IV

Additional Material Submitted for the Record

TESTIMONY FOR THE RECORD

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

REGARDING THE DOE LOW-LEVEL NUCLEAR WASTE PROGRAM

APRIL 29, 1986

SUBMITTED BY GOVERNORS

JAMES R. THOMPSON (ILLINOIS)
RICHARD W. RILEY (SOUTH CAROLINA)
RICHARD F. CELESTE (OHIO)
JAMES BLANCHARD (MICHIGAN)
RICHARD P. LAMM (COLORADO)
RICHARD H. BRYAN (NEVADA)
W. BOOTH GARDNER (WASHINGTON)

Mr. Chairman and Members of the Committee: We thank you for the opportunity to present our views on a matter of vital importance to states and compact regions responsible for developing a low-level radioactive waste disposal facility.

Between now and January 1, 1993, the task of siting and developing several new low-level waste disposal facilities must be completed. But the technological and political issues facing states and compact regions are enormous. This is especially true where the type of facility previously used (shallow land burial) is prohibited or politically unacceptable. Thus, at the same time that studies are being performed to find suitable locations for new facilities, substantial work must also be done to evaluate alternative technological approaches for disposing of low-level radioactive waste.

The extent to which progress is made during the next few years will determine whether a new nationwide system of low-level waste management can be achieved. Technical and financial assistance from the U.S. Department of Energy (DOE) is critical to the success of this effort. DOE has already begun

to facilitate states' efforts by issuing grants for studies related to national low-level waste issues, such as siting and disposal technology evaluation. In addition, the DOE low-level radioactive waste management program, operated by its primary contractor, EG&G Idaho, has a national computer network which includes economic models for evaluating site development and waste disposal costs, waste disposal data for individual states, and a low-level waste manifest tracking system. DOE is also helping sponsor a national coordinating committee for evaluating alternative disposal technologies, has sponsored public participation workshops, has assisted states in developing programs which will facilitate adequate siting schedules and has published numerous proceedings and information documents related to low-level waste management including the annual state-by-state assessment of low-level waste disposal, waste minimization procedures and case histories of local cooperation and incentives.

The financial and technical resources available for completing the tasks required by the Low-Level Radioactive Waste Policy Amendments Act of 1985 are limited, particularly during the critical two-year period just ahead, and they must be used efficiently. DOE can promote this efficiency through the types of activities described above. Sufficient time is not available for each state and region to engage in a "trial and error" approach to evaluating technologies and developing siting procedures. With DOE's assistance, individual states and regions can build on the knowledge of others, and they will not be required to perform these analyses independently.

Unfortunately, at a time when DOE's assistance is most critical, appropriations for the low-level waste program continue to be reduced. The funding level of $6.2 million for Fiscal Year 1985 was reduced to $4.65 million for Fiscal Year 1986. A further reduction (to $4.0 million) is proposed for Fiscal Year 1987. States such as Illinois and Texas, each of which has made significant progress toward developing a new facility, have already felt the impact of reductions in DOE's budget. In each case, the states have been told by DOE that grants previously approved for assisting in the development of new facilities will be available, but at reduced levels, and that no additional assistance to the states will be granted under the funding level proposed in the president's budget.

We strongly urge Congress to reject the proposal by the DOE to reduce the funding level for the low-level waste program. Continued reductions will make the assistance on which states had intended to rely unlikely, if not impossible. This is particularly true in light of recent provisions which were included in the Low-Level Waste Policy Amendments Act of 1985. These provisions place new responsibilities on the Department of Energy including:

1. Conducting a year-long study on "above class 'C' wastes" and "assuming responsibility for such wastes";

2. Managing the allocation of 800,000 cubic feet of disposal capacity provided to utilities for unusual operating eventualities;

3. Managing an escrow account, comprised of 25% of the surcharges that will be rebated to the states and compacts upon achieving specific milestones; and

4. Producing an annual report of the progress of states and regions in meeting the deadlines in the Act and on industry's procedures for handling low-level waste.

Each of these new responsibilities must be funded out of DOE's low-level waste budget which means that the limited resources available to states from DOE will be reduced even further.

While we recognize that the responsibility for implementing a low-level waste management and disposal system now rests with the states, such a system cannot be implemented without full cooperation and assistance from the Federal government. We are convinced that if the Federal government's level of commmitment is reduced at this critical juncture, successful implementation of the system will be placed in serious jeopardy. The cost of failure will be high since if the States are not successful, responsibility for low-level waste may shift to the Federal government. I think you would agree that this outcome would be an unfortunate and costly result.

For these reasons, we urge the Congress to increase the amount available for the DOE's Low-level waste program in FY87.

DEPARTMENT OF DEFENSE
STRATEGIC DEFENSE INITIATIVE ORGANIZATION
WASHINGTON, DC 20301-7100

29 APR 1986

Mr. James W. Vaughan, Jr.
Acting Assistant Secretary
for Nuclear Energy
U.S. Department of Energy, NE-1
Washington, D.C. 20585

Dear Mr. Vaughan:

As a result of our discussion last week, I would like to re-emphasize my support for several nuclear energy programs that are important to the overall success of the Strategic Defense Initiative (SDI). These programs include the SP-100 and Multi-megawatt (MMW) space reactors, the Dynamic Isotope Power System (DIPS), and the Secure Military Powerplant Project (SMPP).

Space reactor systems will be required in the SP-100 power range in order to satisfy the space platform operational power requirements of a space based SDI system. Higher power MMW space reactors are also candidates to meet the pulse power needs of several of the Directed Energy Weapons (DEW) and Kinetic Energy Weapons (KEW) currently being investigated. Key technology and development issues should be addressed in both programs and the ongoing SP-100 Ground Subsystem Test Program and nuclear MMW development programs need to be continued to address these issues.

The DIPS and SMPP Programs are primarily U.S. Air Force initiatives, but because of their potential application to SDI, I endorse them and urge your continued support as part of your cooperative efforts with the Air Force. The DIPS concept is the preferred power source for an operational Boost Surveillance and Tracking System (BSTS) and development should proceed on a time scale that is compatible with overall BSTS development. As part of my overall funding support for BSTS, some SDI funding will be directed toward DIPS development.

As I indicated to you in an earlier letter, the SMPP may be important to ground based SDI assets. The ground based systems are receiving increased emphasis and I encourage you to continue this cooperative effort with the Air Force. Because it is more of a new application of existing technology rather than a new technology or feasibility issue, Air Force funding is more appropriate than direct SDI funding, and I am relying on Air Force funding to help carry this project forward.

As you consider the various program alternatives that the rigid budget constraints force you to consider, I urge you to give a high priority to these programs that are important to the Strategic Defense Initiative.

Sincerely,

James A. Abrahamson

James A. Abrahamson
Lieutenant General, USAF
Director

64-415 O - 86 - 25

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1987

(Nuclear Research and Development Programs)

MONDAY, MAY 5, 1986

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:05 p.m. in room SD-366, Dirksen Senate Office Building, Hon. Pete V. Domenici, presiding.

Present: Senator Domenici.

Also present: Marilyn Meigs, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator DOMENICI. Could we have order, please. We have three different panels today, two with four witnesses and one with two. We are going to try our best to get to all of you, if you will help us here.

We have about an hour and a half. That ought to be enough time, I think. I am not sure we are going to have any other Senators able to attend, so we will do our best to accommodate the witnesses, and you will have to keep the testimony as brief as possible.

Once again, good afternoon to you all. Today we will continue with the second part of the hearing on the Department of Energy's Nuclear Energy Program. During the first hearing on Tuesday, April 29, we received testimony from several administration witnesses representing the DOE, the NRT, the SDIO, and the Air Force. Today we will receive testimony from public witnesses concerning the DOE's nuclear energy programs.

Since April 29, the Russian nuclear accident has caught the attention of the world. The speculations have been rampant. Undoubtedly, the safety of nuclear power will be under scrutiny more now than ever. In order for the United States to maintain the nuclear option for energy independence, we obviously must take a look, and a careful look, at the funding level of nuclear research and development programs, especially on the advanced reactor pro-

gram, to ensure a safe, secure, and economic supply option if and when it is needed.

The budget resolution adopted by the Senate last week recognizes the importance of maintaining Federal funding for the energy R&D programs. It provides, not cuts as recommended by the administration, but a freeze on the energy functions at the fiscal year 1986 level, with an increase of $94 million in the R&D portion of the budget, subject to appropriations action, actual allocation and funding, to bring this back to the same level after inflation.

We are pleased now to have the three panels of public witnesses, and I assume that you are prepared to proceed in the order that was scheduled by the staff. So if the first panel will please come to the witness table: Ms. Edwyna Anderson, chairperson of the NARUC Subcommittee on Nuclear Waste Disposal, Commissioner from the Michigan Public Service Commission.

Thank you very much for coming and we will be right with you. And Mr. Fred Davis, senior legislative affairs representative for Edison Electric Institute.

You may proceed.

STATEMENT OF EDWYNA G. ANDERSON, CHAIRPERSON, SUBCOMMITTEE ON NUCLEAR WASTE DISPOSAL, NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS, AND COMMISSIONER, MICHIGAN PUBLIC SERVICE COMMISSION

Ms. ANDERSON. I am Edwyna Anderson. I am testifying today on behalf of the National Association of Regulatory Utility Commissioners, better known as NARUC, a 96-year-old quasi-governmental association of commissions engaged, among other things, in the economic regulation of investor-owned utilities within all 50 States and territories.

One of our responsibilities is to assure the Nation's ratepayers that all possible efforts are being made to make the nuclear waste disposal program safe, well managed, and cost-effective. We are continuing to advise the Department of Energy and the Congress on the conduct of this necessary but very expensive program.

All ratepayers of utilities operating nuclear electric plants are now being assessed through their monthly electric bills for this decades-long program costing billions of dollars. We emphasize that ratepayers, not utilities, are the source of these revenues.

Our overall findings, including—and I want to emphasize—several successes of the program appear in the full written text, which I request be bound into the record.

Senator DOMENICI. Without objection, it will be so filed.

Ms. ANDERSON. In this limited time, I will highlight five recommendations. The first, in the matter of cost control, we believe the Congress should launch an audit of the enormous program costs. We note the assertions of many that the waste disposal issue is not a technical problem. Focus should be on big ticket items and on those items escalating at an unusually high rate.

Also on program audit and cost control, the General Accounting Office recommended last year that the DOE substantially upgrade, intensify, and make uniform its audit of contractors. Recognizing

that contractors spend 85 percent or more of the program funds, we again bring this essential suggestion for cost control to the attention of the Congress.

Secondly, as to the payments proposal for disposal of defense wastes, we remain concerned over the in camera negotiations over billions of dollars by two Departments within the DOE.

Senator DOMENICI. Over what kind of negotiations?

Ms. ANDERSON. In camera, that is, negotiations between the two units of DOE.

Senator DOMENICI. I understand. I just did not understand you, but I do know what it means. [Laughter.]

Ms. ANDERSON. We believe the Congress must seek adequate release of information and assurance that all interested parties are heard.

Third, as to State and Federal interactions, we, the DOE, and the Congress are disturbed by the elevated emotions and serious loss of communication. We recommend that the Congress determine measures for improvements from those assessments soon to be provided by the General Accounting Office.

Fourth, while the DOE has exerted considerable effort and much program progress has occurred, we are, nevertheless, aware of the continuing slippage of important program milestones and mandated deadlines. Some concern themselves with other aspects of the slippage.

Our concern, based on our varied oversight experience with utility management of nuclear reactor construction, is that substantial slippage means a substantially escalated budget. We cannot overstate this concern. We invite very close Congressional attention to program schedule.

Finally, we have noted that, to its credit, the DOE has new and improved internal management and cost accounting systems. These systems appear to represent effective management tools.

We have not been able, however, to determine whether they are fully and effectively deployed across the widespread DOE organization. We believe the Congress should investigate this matter and also determine whether the traditional DOE organizational approach is indeed the most effective organization of the waste management program. This is a critical question and a central issue is the business of assuring wise use of over $30 billion.

In conclusion, the NARUC is very appreciative of this opportunity to address the Congress toward strengthening of this difficult program. There is a limit to the financial resources of ratepayers that can be devoted to waste disposal. We cannot, in the alternative, sit by and wait for whatever elevated costs may eventually result through fee increases.

Thank you very much.

[The prepared statement of Ms. Anderson follows:]

UNITED STATES SENATE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

TESTIMONY OF THE

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ON THE

CIVILIAN RADIOACTIVE WASTE MANAGEMENT PROGRAM

MAY 5, 1986

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Chairperson Domenici and Members of the Subcommittee:

I am Edwyna G. Anderson, Commissioner of the Michigan Public Service Commission, a member of the National Association of Regulatory Utility Commissioners (commonly known as the NARUC), and its Committee on Electricity, as well as its Subcommittee on Nuclear Issues and its Subcommittee on Nuclear Waste Disposal. I am testifying today on behalf of the NARUC to relate our views on the civilian radioactive waste management program of the U.S. Department of Energy (DOE).

The NARUC is a quasi-governmental, nonprofit organization founded in 1889. Within our membership are the governmental agencies of the fifty states and the District of Columbia, Puerto Rico and the Virgin Islands, engaged in the regulation of utilities and motor carriers. Among other duties, the NARUC is the national representative of state commissions responsible for the economic regulation of utilities now operating nuclear-powered electric generating stations. As such, these commissions have been charged with the task of ensuring that the power provided by such generating stations is reliable, just and reasonably priced -- in short, that the public interest is protected.

My colleagues in state utility regulation and I greatly appreciate your invitation to testify today on an issue of great importance to ratepayers who receive electric service from utilities operating nuclear power facilities --- the implementation of the Nuclear Waste Policy Act of 1982 (the Act). Public utility commissioners across the nation have taken note of the Act and its major effect on their conduct of electric utility regulation, including the impact on ratepayers. First and most important to our mandated responsibilities, all ratepayers of utilities operating nuclear electric plants are now being assessed through their monthly electric bills for the entire cost of an expensive decades-long federal high-level nuclear waste disposal program. Secondly, the orderly, predictable and cost-effective removal of spent reactor fuel from temporary storage at in-state nuclear reactor sites is important to regulators in ensuring public safety and protecting expensive electric production capability. Lastly, the emplacement in a cost-efficient fashion of such highly radioactive wastes in a repository designed and constructed to safely isolate this long-lived radiation is of the utmost importance.

The creation of the Nuclear Waste Fund under Section 302 of the Act results in the assessment of one mill for each kilowatt-hour of electricity generated by nuclear fuel. Despite frequent references to utilities which are called on to collect the money, it is <u>ratepayers</u> who are the source of all high level waste disposal revenues.

For these reasons the NARUC established, by unanimous resolution in 1984, its intention to audit and monitor on an ongoing basis the national nuclear waste disposal program. The NARUC seeks to provide critical information to commissioners in all states and to impart to the the Congress and the DOE the NARUC's unique and extensive nationwide expertise in all aspects of utility regulation so as to enhance the federal program and assure that ratepayer funds are utilized most effectively. To implement the resolution, a standing Subcommittee on Nuclear Waste Disposal was established. This Subcommittee of the Committee on Electricity represents the views and position of the NARUC as contained in this statement.

The NARUC's Involvement in the Federal High-Level Nuclear Waste Program

Our legally-mandated responsibilities in utility regulation bring our commissions in contact with and with jurisidiction over the hundreds of electric utilities we regulate. This responsibility includes decisions on site selection, plant construction, completed plant cost, the prudence of contruction expenses and operational management, and audit of and changes in rate impacts from completed plant costs. This includes the determination of utility prudence and, in some cases of the use of the nuclear option, the disallowance of large sums of money determined to be imprudently expended. In far more cases, both nuclear and fossil, the NARUC member commissions have acknowledged the successful completion of generating plants and full allowance for all expenses incurred.

The driving force behind the NARUC's involvement in the federally-mandated nuclear waste disposal process is the concern for sound fiscal management of the program. Recognizing the technical complexity, the public apprehension, the need for absolute assurance of safety, and the necessity in the public eye for administrative credibility, it is no wonder this program represents a vast financial commitment, now estimated to total $25 to 35 billion. And those program costs are all but assured to increase. My colleagues and I in commissions across the nation are required by law to judge the fiscal bases for the reimbursement by ratepayers of every penny of nuclear waste program payments made by utilities to date.

While we are not experts on all aspects of this enormous project, our activities and evaluations have led to insights from which we have developed several opinions on actions designed to improve the program. In this testimony, I will review for you three areas:

1. I will review some of our activities in order to indicate our interests and approach.

2. I will review the areas of the program of most concern to the NARUC.

3. I will offer several suggestions for improvement of the program that the Congress may wish to consider.

You will note that in none of these observations do we presume to render technical judgments. We recognize the important role the Act has thrust upon us, but we also note that there are many other entities and institutions, also with special expertise, that have a part to play in this unfolding effort.

THE NARUC ACTIVITIES

The NARUC's activities, in discovering, understanding and evaluating the federal and state effort mandated by the Act, have brought us in direct contact with the U.S. Office of Technology Assessment, the U.S. General Accounting Office (GAO), the Edison Electric Institute, the U.S. Nuclear Regulatory Commission (NRC) and in repeated contact with the managers and directors of the DOE program. We have also been in frequent contact with the members and staff of the Congress of the United States and have testified on these matters before the Congress on four prior occasions.

Our past and present actions, in addition to informal contact with and advisement of those we have interviewed, include formal notification of the NRC of our continuing interest in a cost-effective, timely, deliberate and predictable repository licensing program. In response to the DOE's request, we will render advice on its conduct of financial grants to states and Indian tribes. We will make recommendations to the DOE with respect to audit of their contractors. We have made known our view of the extreme importance of the issue of federal payments to the Nuclear Waste Fund for the disposal of national defense nuclear wastes and will respond to the formal federal request for comment on the payments proposal that is promised to be released soon.

THE NARUC AREAS OF CONCERN

With little surprise, the NARUC has concluded that the complex task mandated by the Act and assigned to the DOE and the states is an arduous one. Important rights are assigned to both parties to be carried out in the face of the great public apprehension that this program generates. Since our main goal is an efficient, cost-effective, successful program, we are especially concerned that our efforts assist, not detract from, the program. Nevertheless, we will speak out wherever we discover possibilities for program improvement to enhance the effectiveness and the control of ratepayer funds devoted to this national task.

With respect to the overall program, we conclude that there are many well-managed aspects, and recognize that too often in heat of battle over siting that these accomplishments have not surfaced. Mere accolades are not our intent; rather, program strengths, as we see them, are important to be identified and can be used as guides or foundations for the strengthening of weak or undeveloped parts of the overall program.

We believe the office director is a competent program manager, one who has been very cooperative with us, and that he has assembled the most extensive and competent central staff ever to work on the high-level waste program. The Congress has arranged his position within the DOE at an authoritative level to overcome many of the deficiencies that occurred in similar efforts over the last 30 years. The new organization has tackled many mandated, difficult problems including the siting of the first two repositories, the development and siting of the Monitored Retrievable Storage facility (MRS), the publication of the Mission Plan, the funding of grants to states and Indian tribes, licensing activity by the NRC, optional reviews by the National Academy of Sciences, accumulations of fees and the coordination and production of management control methodologies

and budgetary controls. We note further that some respect for and commendation of the DOE has been received; an example is the letter of the National Academy of Sciences dated April 10, 1986.

Believing our insights and observations can help to improve management and cost control and to aid success, the NARUC finds it important to release these observations of the program and its conduct in the hopes of focusing attention on any necessary corrective response at present time.

1. Integration of Defense Waste into the Waste Disposal Program

The Defense Programs Office of the DOE has negotiated with the waste management office, in camera, to determine an equitable allocation payment formula for defense waste disposal. The NARUC is concerned with the conflict of interest in two divisions within the DOE negotiating with each other on such an important public issue. The NARUC is concerned that the interest of ratepayers may not be adequately protected in such negotiations. In fact, the DOE budget could benefit from an agreement that allows the disposal of defense wastes to be subsidized by ratepayers. Following an agreement, the terms will be published in the Federal Register for comment; however, the agent to determine information to be released, and to receive and resolve all recommendations and critique is the Department itself. The resolution process appears to the NARUC not to be very amenable to outside suggestion and gives no encouragement to thoughtful and concerned parties. We believe the Congress should exert significant attention to assuring that sufficient information to allow informed comment is released, and that the rights of all interested parties are protected throughout the resolution of this matter.

2. State and Federal Interactions

One major concern to the NARUC is that of the interaction between states and federal waste authorities. We have observed before that, despite renewed efforts on the part of the DOE, problems of credibility, and limited progress plague the program. This matter has been reviewed for us by the DOE waste office director and acknowledged by members of the Congress. It appears that important siting decisions in both the first and second repository program may have contributed to escalating the already elevated rhetoric and emotions. We are aware of the problem and its seriousness; we recommend that the Congress continue to concern itself with this issue and look to the intensive evaluation of state and federal relations now being completed by the GAO. We believe this assessment should provide the Congress with some means to seek improvement in this all-important interaction.

One major aspect of state resistance to the DOE's conclusions rests on the technical conclusions DOE has reached or is reaching concerning site selection. Most states object on technical grounds to the sites being studied by the DOE. The NARUC is seriously concerned with the threat to program progress necessitated by possible revision of the sites under consideration. If such reconsideration is necessary, the most cost-effective time for revision is as early as possible. Such conclusions will be the most important test to date of the

federal competency and a great determinant of public confidence. We believe the Congress should continue to monitor the situation and be ready to insert itself into the program to assist the DOE and the states if major disruptions occur.

In this matter we observe that the DOE is committed to interaction with state, utility and ratepayer representatives and to individual contact with members of the Congress and official interaction through hearings such as this one. However, there is no central, joint, periodic meeting of all the major concerned parties for the purposes of program review and assessment, and the necessary periodic revisions to accommodate successes and failures and to chart a revised next-period cost-effective program. This leads to difficulty among the responsible parties in appreciating the point of view of the other parties and in being able to advise and influence the program. In essence, it restricts program directional changes to a series of two-party interactions with the DOE which opinions are, sometimes in conflict; places the DOE in the position of responding to diverse criticism, and makes the Congress's influence over the program more remote by leaving it to review largely overall aspects through the hearings process.

3. DOE Problems in Meeting Deadlines

As to progress in moving the program ahead, despite the acknowledged DOE movement on site selection and towards characterization, deadlines continue to slip. The DOE now projects a slippage of four and eight years, respectively, for Presidential recommendation to the Congress of sites for the first and second repositories. The projected dates are five and twelve years, respectively, in the future. To us, this indicates that the program may not be on the schedule that the DOE has published. If so, that fact has a differing importance to the concerned parties. For example, to those primarily interested in spent fuel removal, it means the 1998 fuel acceptance deadline that DOE adheres to is threatened. To the NARUC, it represents something else of surpassing importance. Utilizing our experience with nuclear reactor construction projects, we recognize that a program that is not on schedule is one that is not under cost control. An indeterminate schedule is synonomous with indeterminate cost. We cannot over-emphasize the degree of importance the NARUC attaches to this concern, for you must understand the number of reactor projects our commissioners lived with through repeated cost and schedule revisions over many years. In a few cases, the end of the process was an abandoned, extremely expensive failure. We believe the Congress also must be very concerned with this matter of cost and schedule and should stay in close contact with the DOE on this matter.

4. Overall Program Audit and Cost Control

One aspect of overall program audit and cost control that has caught our attention is the matter of overall waste budget review. There are two portions of the budget that we believe would be well to be examined. First, we are stunned by the enormous size of the waste program budget, especially noting the years-long assertion of the industry and technologists that high-level waste disposal is "merely" a political problem, not a technical one. We believe it would be

very insightful if the Congress were to launch an audit of the cost of the total overall waste program, especially now when there is some indication that the DOE may request a waste fee increase. The two most important aspects of the review should be the evaluation of major or "big ticket" items; and those tasks, large or not, that have shown a substantial increase in estimated cost over the last few years. Another major item we believe should be examined in this audit is the ability and facility of the DOE to manage the program delays in one portion of the program so as to prevent cost increases in other parts or throughout the program. Perhaps with such an audit the Congress could identify authority, program revision or organizational changes that the DOE might need to assure adequate cost control.

5. Project Management and Control

The last area of interest that we wish to illuminate is that of project management in overall cost control. Our observations follow from our concerns on project schedule and reflect our earlier listed respect for the organizational improvements made under the waste office director. Nevertheless, there are several matters that appear to be necessary to bring to the attention of the Congress. They are intimately associated with the functionally and geographically distributed nature of the DOE headquarters staff, deployed geologic offices and project control offices. As you know, not all the staff of the DOE working directly on the waste program operate out of the Washington office or report directly and fully to the waste office director.

With that in mind, we wish first to mention program contractor audits, recognizing that 85 percent or more of the totally ratepayer-funded waste budget is spent by the DOE's contractors. The GAO recommended in its annual audit of 1985 that the DOE should substantially upgrade, intensify and make uniform its audit of contractors. We observed that recommendation with great interest and have previously brought that matter to the attention of the Congress. The Senate leadership of this committee has indicated its belief that the waste program does not receive as much audit and oversight as programs funded by general tax revenues; this in a letter urging on the GAO. Despite these views, the DOE has seen fit largely to resist these recommendations for strengthened audit of contractors.

We noted earlier that the DOE, to its credit, has established new and improved management systems and cost control procedures. We believe that, if effective and pervasive in use, these measures can make a considerable contribution to organizational control and to cost control. Our investigative efforts to date have been limited by the time, people, expertise and expense we can contribute to this very large program, so we have been unable to determine whether the DOE's measures have been deployed throughout all the waste program offices and contractors to assure effectiveness in usage. We believe the Congress should also be concerned with this aspect of the question of control over regional office operations and contractor expense.

Lastly, with respect to the DOE organization, we have observed the large question that the Congress also raised in the Act, that of whether the DOE's geographically distributed organization with its project control located at the regional office level is the best approach to managing the nuclear waste

program. We observed with great interest the examination of this question and the recommendation of an earlier blue-ribbon panel reporting to the Secretary of Energy.

We continue to believe this is an important question that has potentially large ramifications on the use of ratepayers' funds. At the least, this organizational set-up puts added stress on the waste office. We are aware of real or alleged errors and deficiencies in the control of contractors in other DOE programs. The DOE itself has acknowledged possible value in future reorganization of its waste management organization. We believe this is a central issue in the business of trying to assure that a projected $30 billion assessment is utilized wisely.

The NARUC SUGGESTIONS FOR IMPROVEMENT OF THE WASTE PROGRAM

We conclude our testimony with several suggestions for program improvement that we believe the Congress may wish to implement:

1) Assess the GAO report on state-federal relations to determine measures needed to improve interactions and reduce friction.

2) Determine, in the face of growing concern over state-public-federal relations, if it is in the interests of all for the Congress to establish under its direction, a means for discussion, dialogue, resolution and mediation among all major parties which would include the DOE, the states, the utilities, the ratepayers and interested citizen groups. The purpose would be to resolve issues, conserve funds, ease tensions and reduce litigation.

3) Require an order for periodic, intensive uniform audit by the DOE of all contractors, with audit scope, schedule and depth dependent on the level of funding and the importance of the contribution to the overall waste program and with GAO oversight of the DOE audit process;

4) Call for an independent intensive review of the total cost of nuclear waste program from its inception in 1982 to its conclusion in the next century; with high cost items and those for which estimates have risen substantially to be identified for special examination and review;

5) Review overall management organization of the DOE's waste program; with examination of the utilization and effectiveness of the budget control program and the management systems that have been employed. The question is whether, with the distributed organization and management authority, waste office efforts are fully effective in assuring all regional office, DOE contracting office, program manager and contractor efforts are coordinated, efficient and under adequate control, so that the waste fund is efficiently utilized. The corollary

question is then whether, in the face of delays, the waste office is sufficiently authorized and empowered to prevent unnecessary work in one area when delayed by interruptions or problems in another.

6) Elicit an expert examination of the issue of whether the organization of the waste program, which is within the traditional structure of the DOE's management system, is optimal for getting the waste disposal job done in a safe, successful and cost-effective manner.

CONCLUSIONS

We of the NARUC have greatly appreciated this opportunity to speak to the Congress on this program of such national importance. We reiterate our understanding of the very difficult task the disposal of high-level waste represents and our pledge to do everything reasonably in our power to assist in achieving a successful completion of the disposal program by the DOE. While we may have raised some sensitive issues, we must acknowledge our pledge to ratepayers that we will not sit by and let program impediments unnecessarily raise costs that are taken from their pockets. There is a legitimate cost for disposal that ratepayers must bear, but we also note that there is a limit to the financial resources that ratepayers have for high-level nuclear waste disposal.

Thank you again.

Senator DOMENICI. How much are the ratepayers—you indicated they are paying into this fund and you are right. What is that rate?

Ms. ANDERSON. One mill per kWh.

Senator DOMENICI. What is that that I as a ratepayer would understand?

Ms. ANDERSON. We estimate that, of the $25 to $30 billion currently, with the kind of estimates that are going around with regard to defense wastes, that the ratepayers would pay something in the neighborhood of $22 to $27 billion.

Senator DOMENICI. It will be less than the $30 billion, and we have not decided where yet. But I mean, for an average residential bill, we say they are paying—what are they paying?

If it is a $14 bill, how much of that goes to this fund?

Ms. ANDERSON. Excuse me. I am conferring with one of my staff members who has those figures.

[Pause.]

Ms. ANDERSON. I understand for a 500-kWh bill it would be roughly 50 cents per month per ratepayer.

Senator DOMENICI. 50 cents per month?

Ms. ANDERSON. Per ratepayer.

Senator DOMENICI. And that standard bill would be how much? Would you be able to do the arithmetic if it is one mill? But do you know? $25, is that the right number?

Ms. ANDERSON. $25 to $35.

Senator DOMENICI. $25 to $35 for that 500-kWh, and they are paying 25 cents—or 50 cents.

Ms. ANDERSON. 50 cents.

Senator DOMENICI. 50 cents, all right.

Well, we thank you very much for your suggestions. We too are concerned, obviously, about the enormous cost of this program, and obviously it has got a lot of other problems. Clearly, we do not want it to get bogged down in situations where money is being wasted.

So we thank you for your suggestions, and we will make your entire statement a part of the record. Would you wait and let the other gentleman testify, and then perhaps we will ask both of you some questions.

Ms. ANDERSON. Certainly. Thank you.

Senator DOMENICI. Would you please proceed.

STATEMENT OF FREDERICK G. DAVIS, SENIOR LEGISLATIVE AFFAIRS REPRESENTATIVE, EDISON ELECTRIC INSTITUTE

Mr. DAVIS. Thank you, Mr. Chairman. My name is Frederick G. Davis, senior legislative representative for the Edison Electric Institute.

EEI is the association of investor-owned electric companies. Its members operate 85 nuclear plants, with 17 additional units under construction.

The Utility Nuclear Waste Management Group, on whose behalf I also testify, is a specific activity of 44 nuclear utilities who have joined together to assist in the nuclear waste disposal process. These nuclear utilities hold the majority of DOE's nuclear waste

disposal and domestic uranium enrichment contracts. The full cost of both programs are covered by utility payments, totaling $1.4 billion in fiscal year 1986.

The nuclear power utilities and their electric customers at present are the sole funders of DOE's Nuclear Waste Policy Act, NWPA, implementation. This is at a current rate of about $390 million per year from the one mill per kilowatt-hour charge.

Today we wish to focus on four issues that we believe are important to the success of the nuclear waste disposal program. The NWPA directs DOE to develop and present to Congress a proposal for a monitored retrievable storage facility, but Congress reserved for itself the final decision on whether the nuclear waste program should include the MRS. DOE's improved performance plan, as proposed in its June 1985 mission plan, includes an integral MRS, I-MRS.

We strongly support the I-MRS and are pleased to note that on March 13, 1986, the EEI board of directors unanimously approved a resolution supporting the facility. A copy of the resolution is attached to this testimony. It urges Congress to direct the DOE to proceed with the I-MRS and to implement the improved performance plan described in that June 1985 mission plan.

The I-MRS concept envisions a facility that would perform a essential nuclear waste disposal function. These essential functions would be performed whether or not there is an I-MRS. However, locating these functions at the I-MRS would provide significant benefits to the overall nuclear waste program. The I-MRS would make the nuclear waste disposal program less sensitive to delays in the schedule for the initial repository.

Other significant benefits from the I-MRS include improvements in the waste transportation system. Also, it would have DOE address transportation related issues at an earlier stage than the siting of the nuclear repository. Perhaps the greatest advantage to the nuclear waste disposal program for the I-MRS would be the requirement to mobilize DOE's design, licensing, and construction forces several years before they would be required for a repository-only program.

This would serve to focus DOE's implementation of a significant part of the NWPA at the earliest possible time. Such early focus for at least a portion of the program is essential, given the extended duration of the overall program and the enormous costs involved.

We strongly urge Congress to approve the MRS to maximize benefits for the utilities and the overall implementation of the Nuclear Waste Policy Act. In order to maximize benefits for the utility storage planning, we also request that Congress permit MRS to accept a significant quantity of spent fuel prior to the construction authorization of the first repository.

The President has determined that high level radioactive waste resulting from atomic energy defense activities and civilian spent fuel and waste should be disposed of in the same repositories. However, the DOE Defense Program has not contributed any funds, while the utilities have paid in over $2 billion.

We share the concerns of the National Association of Utility Commissioners that DOE's internal considerations may be only to

justify the lowest possible cost allocation to defense wastes. Our preliminary studies indicate that the fair and equitable share for defense wastes should be in the area of about 30 percent.

We urge Congress to insist that DOE take prompt action to correct this inequity, with payments to be made in fiscal year 1986 or, at the very least, in fiscal year 1987. The most recent estimates of the total nuclear waste program in cost is in the range of $24 to $32 billion. Electric utilities and their customers are now paying for services promised at some future time.

We recommend that DOE take further steps to centralize management and coordination, perform systematic and continuing audits of contractors, and establish by rulemaking specific guidelines for grant applications from States and Indian tribes.

When Congress passed the NWPA, it believed that the schedule established was realistic and fully expected that the Federal agencies would do everything possible to assure that the schedule would be met. The first repository site recommendation is now set for March 1991, 4 years later than the deadline established by Congress.

The consequences of schedule delays will be increases in the program's costs and an erosion of the public confidence in the Federal Government's ability to dispose of nuclear wastes safely. Congress should encourage the DOE to comply as closely as possible with the schedules established by the Congress and to report both actual and anticipated problems, along with proposed means for mitigating further slippages.

I would like to turn for a moment just to a couple of other nuclear civilian items in the budget other than wastes.

First, uranium enrichment. We agree with the proposed expenditures by DOE in the fiscal year 1987 budget request for the uranium enrichment activity, with the exception of the payment to the U.S. Treasury of $235 million. We strongly oppose the implied concept that the uranium enrichment enterprise owes a large amount of money to the Treasury for prior unrecovered costs. On April 24, 1986, EEI submitted a detailed statement on this subject to the subcommittee.

The cleanup of Three Mile Island Unit 2 is progressing and the damaged material is expected to be removed from the reactor by the middle of 1986. The investor-owned electric utility industry is providing $150 million toward the cleanup over a period of 6 years.

Continuation of Federal research and development funding, in addition to the industry funding, is vitally important to the cleanup program and to assure that the maximum amount of research and development information is obtained. We urge that Federal funding be continued to provide important knowledge for nuclear plant design, operation, and decommissioning.

Mr. Chairman, that concludes by oral comments and I would be pleased to answer any questions.

[The prepared statement of Mr. Davis follows:]

EDISON ELECTRIC INSTITUTE
AND
UTILITY NUCLEAR WASTE MANAGEMENT GROUP

TESTIMONY PRESENTED TO

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ON THE

FISCAL 1987 CIVILIAN NUCLEAR
RESEARCH AND DEVELOPMENT PROGRAM
DEPARTMENT OF ENERGY

MAY 5, 1986

Mr. Chairman and Members of the Subcommittee, my name is Frederick G. Davis, Senior Legislative Affairs Representative for the Edison Electric Institute (EEI). EEI is the association of investor-owned electric companies. Its members operate eighty-five nuclear plants with seventeen additional units under construction. The Utility Nuclear Waste Management Group (UNWMG) is a specific activity of forty-four nuclear utilities who have joined together to assist in the nuclear waste disposal process. These nuclear utilities hold the majority of DOE's nuclear waste disposal and domestic uranium enrichment contracts. The full cost of both programs are covered by utility payments -- totaling $1.4 billion in FY 1986.

DOE'S NUCLEAR WASTE DISPOSAL PROGRAM

The nuclear power utilities, and their electricity customers, at present are the sole funders of DOE's Nuclear Waste Policy Act (NWPA) implementation. This is currently at a rate of about $390 million per year from the one-mill per kilowatt hour

charge. Today we wish to focus on four issues that we believe are important to the success of the nuclear waste disposal program.

Integral Monitored Retrievable Storage (I-MRS)

The NWPA directs DOE to develop and present to Congress a proposal for a Monitored Retrievable Storage (MRS) facility, but Congress reserved for itself the final decision on whether the nuclear waste program should include the MRS. DOE's Improved Performance Plan, as proposed in its June 1985 Mission Plan, includes an Integral MRS (I-MRS). We strongly support the I-MRS and are pleased to note that on March 13, 1986 the EEI Board of Directors unanimously approved a resolution supporting the I-MRS. A copy of the resolution is attached to this testimony. It urges Congress to direct DOE to proceed with the I-MRS and to implement the Improved-Performance Plan described in the June 1985 Mission Plan.

The I-MRS concept envisions a facility that would perform essential nuclear waste disposal functions. These essential functions will be performed whether or not there is an I-MRS. However, locating these functions at the I-MRS, would provide significant benefits to the overall nuclear waste program. The I-MRS would make the nuclear waste disposal program less sensitive to delays in the schedule for the initial repository.

Other significant benefits from the I-MRS include improvements in the waste transportation system. Also, it would allow

DOE to address transportation-related issues at an earlier stage than the siting of the initial repository.

Perhaps the greatest advantage to the nuclear waste program for including an I-MRS would be the requirement to mobilize DOE's design, licensing and construction forces several years before they would be required for a repository-only program. This would serve to focus DOE's implementation of a significant part of the NWPA at the earliest possible time. Such early focus for at least a portion of the program is essential given the extended duration of the overall program and the enormous costs involved.

We strongly urge Congress to approve the I-MRS to maximize benefits for the utilities and the overall implementation of the Nuclear Waste Policy Act. In order to maximize benefits for utility storage planning, we also request Congress to permit I-MRS acceptance of a significant quantity of spent fuel, prior to construction authorization of the first repository.

Defense Waste Contributions

The President has determined that high-level radioactive waste resulting from atomic energy defense activities and civilian spent fuel and waste should be disposed in the same repositories. However, the DOE Defense Program has not contributed any funds, while the utilities have paid in over $2 billion. We share the concerns of the National Association of Utility Commissioners that DOE's internal considerations may be only to justify the lowest possible cost allocation to defense wastes. Our preliminary studies indicate that the fair and equitable

share for defense wastes should be about 30 percent. We urge Congress to insist that DOE take prompt action to correct this inequity with payments made in FY 1986, or at the very least, in FY 1987.

Cost Controls

The most recent estimates of the total cost of the nuclear waste program is $24 - 32 billion. Electric utilities and their customers are now paying for services promised at some future time. We recommend that DOE take further steps to centralize management and coordination, perform systematic and continuing audits of contractors, and establish (by rulemaking) specific guidelines for grant applications from States and Indian Tribes.

Schedules

When Congress passed the NWPA it believed that the schedule established was realistic and fully expected the federal agencies to do everything possible to assure that the schedule would be met. First repository site recommendation is now set for March 1991 -- four years later than the deadline established by Congress. The consequences of schedule delays will be increases in program costs and an erosion of the public confidence in the federal government's ability to dispose nuclear waste safely. Congress should encourage DOE to comply as closely as possible with the schedules established by Congress and to report both actual and anticipated schedule problems along with proposed means for mitigating further slippages.

OTHER NUCLEAR TOPICS OF IMPORTANCE TO THE UTILITIES

Uranium Enrichment

We agree with the proposed expenditures by DOE in the FY 1987 budget request for the uranium enrichment activity with the exception of the payment to the U.S. Treasury of $235 million. We strongly oppose the implied concept that the Uranium Enrichment Enterprise owes a large amount of money to the Treasury for prior unrecovered costs. On April 24, 1986 EEI submitted a detailed statement on this subject to this Subcommittee.

Three Mile Island Research Funds

The cleanup of TMI-2 is progressing and the damaged fuel material is expected to be removed from the reactor by the middle of 1987.

The investor-owned electric utility industry is providing $150 million towards the cleanup over a period of six years. Continuation of federal research and development funding, in addition to the industry funding, is vitally important to the cleanup program and to assure that the maximum amount of research and development information is obtained. We urge that federal funding be continued to provide important knowledge for nuclear plant design, operation and decommissioning.

Thank you for the opportunity to present the views of the electric utility industry on these civilian nuclear elements of the DOE FY 1987 Budget Request. We would be pleased to answer any questions you may have.

Senator DOMENICI. Thank you very much.

Let me ask both of you some questions, and either of you can answer first, whoever prefers. Let me first note that it is rare that utilities and their regulatory bodies agree closely on much of anything. Yet, your statements indicate that there are some clear areas of agreement.

One is the defense program contributions to the waste fund. Could you both comment on DOE's March report on the adequacy of the nuclear waste fund fee, especially with respect to DOE's initial estimate that the contribution should be $3.4 billion?

Ms. ANDERSON. Well, we certainly think that that is not sufficient. We would be in accord with EEI that it ought to be in the neighborhood of 30 percent or so in terms of equity.

Senator DOMENICI. What do each of you base your 30 percent on if the $3.4 billion is not correct? Where do you get the 30 percent?

Mr. DAVIS. Mr. Chairman, we have done some studies and provided an analysis of the type of methodology we went through to obtain the figure we came up with, and we have submitted that to this committee in a hearing that was held last fall.

I would be pleased—I brought that statement along and I would be pleased to give a detailed summary.

Senator DOMENICI. Could we have that again? We will make it a part of the subcommittee files.

Mr. DAVIS. Yes, sir.

Senator DOMENICI. I understand, then, that you both plan to comment when the formal notice of the defense program contributions to the waste fund is printed in the Federal Register?

Ms. ANDERSON. Yes, that is correct. We certainly intend to do so. We think, however, it would be important to be a part of the negotiations, to have something other than the two programs within the DOE negotiating for those moneys.

Mr. DAVIS. We also will be providing comments to the Federal Register notice.

Senator DOMENICI. All right.

Let me ask, if you were going to prioritize the waste program activities, how would you rank the importance of, first, the repository, second the second repository and MRS activities?

Mr. DAVIS. We would prioritize as follows. We think the first repository is the top priority. We think the MRS would be the second priority, with the second repository being the third, among the three.

Senator DOMENICI. Do you have any opinion?

Ms. ANDERSON. We have taken no opinion with regard to whether or not there should be an MRS. We think that it ought to be viewed in the total context of the program, and very carefully at that.

With that in mind, our first priority would be the first repository, and perhaps the MRS, and then the second repository, assuming that all things go well with regard to the MRS.

Senator DOMENICI. Mr. Anderson, even though you have put MRS in the second priority, and even though it will add some costs to the nuclear waste program, do you believe it is a worthwhile program and that the utilities and ratepayers can benefit from it?

Mr. DAVIS. We do believe—we believe the MRS is a very important part of the overall nuclear waste program.

Senator DOMENICI. She is Anderson, you are Davis, right? Excuse me.

Mr. DAVIS. Do you still want to hear my answer?

Senator DOMENICI. I already heard it.

Mr. DAVIS. We still think it is important. The things you do with the MRS would have to be done at the site of the first repository anyway, and given the lessons we can learn about licensing and some of the hardware experiences you could have with the MRS, it is indeed a critical part and a top priority for us.

Senator DOMENICI. I am not sure that this makes any—that we really understand it yet, but maybe, Mr. Davis, you might comment on it. The 1987 budget request from the Department asks for $47 million to proceed with MRS and $79 million to proceed with their work on the second repository.

Does that sound out of focus to you in any way?

Mr. DAVIS. Only on the face, looking at the numbers, without looking at the budget justifications, it looks like it could have been a misprioritization of funds. But Mr. Chairman, I have not looked at the DOE budget documents and the specific language or direction they choose to spend their moneys.

So I would hesitate to make any evaluations, other than knowing the figures do exist.

Senator DOMENICI. If we do not have enough money for all of the activities, and in view of the fact that the overall schedule delays in the first repository program were obvious, would you—and this is directed at either of you—prefer to see a reduction in the second repository activities for the next several years in order to allow DOE to focus more of its resources and personnel on the first repository activity and all the matters related to it?

Or would you prefer that we keep moving on all fronts, even if we are not fully funded?

Mr. DAVIS. I understand, on behalf of the utilities, we would, given that type of question, I think that with the schedule slippages we have seen already and some of the other problems we see down the road, if we have to prioritize, if the program thought it was in the best interest of the program, given its oversight, to move those moneys around to beef up the MRS or the first repository program, we certainly would think that would be appropriate.

Ms. ANDERSON. I would think we would certainly agree with that. The question is that time is money and those slippages are going to mean a great deal in terms of costs if we are not very, very careful. And we would simply want to see that, whatever happens, the most cost effective and safe, of course, process takes place.

Senator DOMENICI. Ms. Anderson, you stated—I believe you have indicated that the interaction between the States and Federal authorities has been less than desirable. Is your organization—it is your organization that identified the fact that there is no central joint periodic meeting to assess progress in the program.

What do you suggest that Congress do to assert more influence on this program and this shortcoming, if it is one?

Ms. ANDERSON. That there be some organized means of discussion and mediation to resolve the issues and to conserve funds and to alter somehow the course of litigation that is taking place in the absence of this strong centralized program oversight.

We see individual groups going in to the DOE and having impact one day and not so much impact the next. And we think there ought to be some more centralized focus.

Senator DOMENICI. Do you have any suggestions?

Mr. DAVIS. No specific suggestions, Mr. Chairman. The Congress has exercised a great deal of oversight over the program and we have a lot of confidence in Mr. Ruche, and we will continue, on behalf of our ratepayers, to follow it as well.

Senator DOMENICI. My last question to you, Ms. Anderson, is you have stated in your statement that a program that is not on schedule is one that is not under cost control. I assume you have gathered considerable experience in that regard with construction of nuclear plants?

Ms. ANDERSON. That is correct.

Senator DOMENICI. Unfortunately, it just appears to us that DOE has been under attack on nearly every issue of the program. The pending lawsuits—and there are a number of them—will further delay the process. With the experience that you and your organization have had concerning the nuclear plant construction, do you have any suggestions on how we might bring this program back on track?

Ms. ANDERSON. We think that contractor audits are extremely important. We think that management is going to play an extremely important role. We think that has been one of the factors that has caused the problems with regard to power plant construction, is ineffective management.

So we think whatever measures can be taken—and we know that the DOE and Mr. Ruche are taking certain internal measures now. But we would just encourage that we recognize that there is a 1998 deadline and there must be some attention paid to those dates.

Senator DOMENICI. Thank you very much.

Do either of you have anything further you want to add to the record?

Ms. ANDERSON. No.

Mr. DAVIS. No.

Senator DOMENICI. We thank you very much, and I apologize for mixing your names up.

Mr. DAVIS. That is quite all right.

Senator DOMENICI. Let us take the next panel: Dr. Till, associate laboratory director for engineering research from Argonne; Dr. Joseph S. Armijo, manager, nuclear systems technology operation from General Electric; John McDonald, division director of atomics international, Rockwell International; Dr. Howard Arnold, general manager of Westinghouse Advanced Energy Systems.

Let us proceed in the way we were listed on the panel. Dr. Till, you are first; Mr. McDonald, Dr. Armijo, and Mr. Arnold.

STATEMENT OF DR. CHARLES E. TILL, ASSOCIATE LABORATORY DIRECTOR, ENGINEERING RESEARCH, ARGONNE NATIONAL LABORATORY

Dr. TILL. Thank you, Mr. Chairman. I am Charles Till, Associate Laboratory Director for Engineering Research at Argonne, and I am responsible for Argonne's reactor development program.

I am very grateful for the opportunity to appear today. I wish to direct my remarks to the civilian advanced reactor program. This committee is certainly very well aware that the civilian reactor program has a strong rationale and a justification on its own, and the major purpose of that program is obviously the development of a truly superior advanced reactor system.

It is my hope today that in sharing with the committee the recent progress on the integral fast reactor that it will become clear that in the past year or so the civilian program has made remarkable progress in that direction. The goal of IFR development is a new reactor technology whose central element is foolproof, fail-safe inherent reactor safety, inherent simply in the materials used in the reactor and specifically not dependent for ultimate safety on human operators and mechanical systems.

We have made impressive progress on this in the last year. Last-mark IFR tests were carried out on April 3 on our EBR–II reactor in Idaho. They were spectacularly successful. Because of their importance, I want to describe them very briefly in a moment or two.

It is simply a fact that the events of the past week or so in the Soviet Union make the crucial importance of tests of this kind dramatically evident. At this time, we can only guess what the implications of the Soviet accident are on the future of civilian nuclear power. But at the very least, they make even more certain the need to emphasize in the civilian advanced reactor program developments that promise breakthrough improvements in reactor safety.

I should digress for a moment to say that the IFR is not just a new design. It is an entire reactor system based on new technology and complete in every regard—an inherently safe reactor, radically new processes for fuel processing, fabrication, and waste management.

It is in the R&D stage. Development was initiated less than 2 years ago. But it has moved remarkably quick from the idea stage to the feasibility demonstration. In my prepared testimony, I have listed the progress in the various areas.

But most importantly, in light of the current events in the U.S.S.R., I think is the subject of inherent safety and our progress in that direction. On April 3, two IFR safety tests of historic importance were conducted of EBR–II. Their purpose was to show that reactors of the IFR type are extraordinarily and inherently safe.

Within hours of each other, two potentially very severe accident situations were initiated while the plant was operating at full power and with the safety systems disabled. Each was a classic most severe postulated accident, the first the loss of flow without scram and the second the loss of heat sink without scram. And as I say, in both the safety systems were disabled.

In both events, the plant simply shut itself down harmlessly, without any action on the part of the operators or any mechanical system. The reactor was left in each event, after each event, ready to be restored to full power in the normal startup way.

The possibility of reaching this level of invulnerability was undreamed of even a few years ago. These accident simulations were the most severe of their kind ever attempted on any reactor without damage of any kind. No other reactor type that I am aware of could have survived.

And EBR–II, the behavior of EBR–II, is completely prototypical of IFR's in general. That is really the central point. The tests demonstrated not only that EBR–II is unharmed by such accidents, but more than that, that any properly designed IFR of any size would be unharmed as well.

In the simplest terms, we forced accidents to occur that are the most plausible serious mechanical failures that could be postulated to happen in a nuclear power plant. The result was completely harmless.

The entire promise, though, of the IFR is as a self-contained civilian reactor system complete in every regard. The next step is the demonstration of the revolutionary new fuel cycle process.

It can be demonstrated cheaply in EBR–II, and this has been our plan. The President's budget sharply cuts the IFR technology development, and to maintain the IFR program and to move forward with EBR–II IFR fuel cycle demonstration Argonne is left in the position of needing a $19.3 million increment for fiscal year 1987 targeted specifically to the IFR.

In summary, Mr. Chairman, I would like to make the following recommendations. First, the balance between civilian and defense advanced reactor development needs to be restored. The precipitous decline in civilian reactor development support should be reversed.

Second, that R&D and design on an advanced reactor system must focus on breakthrough type characteristics. Current events only emphasize the need for a high degree of inherent safety, probably only achievable by a new advanced reactor type based on new technologies and principles.

The IFR concept is defined by such characteristics. Its development has been extraordinarily successful to this point, and it should proceed with the next major milestone, the demonstration of fuel cycle in the EBR–II complex.

Mr. Chairman, I thank you for this opportunity.

[The prepared statement of Dr. Till follows:]

Statement of

Charles E. Till

Associate Laboratory Director
Engineering Research
Argonne National Laboratory

To the

Subcommittee on Energy Research and Development
of the
Committee on Energy and Natural Resources
United States Senate

May 5, 1986

Mister Chairman, members of the Subcommittee, I am Charles Till, Associate Laboratory Director for Engineering Research, Argonne National Laboratory. I am responsible for Argonne's Reactor Development Program. I am grateful to this Committee for your invitation to appear today.

I wish to concentrate on just a few main points. First is the proposed change in the direction and emphasis of DOE advanced reactor development from civilian to defense applications. Second, I wish to make a few comments on the civilian reactor development program, and to bring this Committee up-to-date on the progress in the last year in the development of the Integral Fast Reactor (IFR) concept. Finally, I wish to share our views on the FY 1987 budget as it specifically impacts IFR development and the major reactor development capability at Argonne National Laboratory, and to offer our recommendations for consideration by this Committee.

Mister Chairman, as you and the Committee are well aware, the Department's FY 1987 budget request contemplates a radical change in the fundamental direction and purpose of federally-supported reactor development, from civilian to defense applications. This Committee certainly knows that the civilian reactor development program has a national purpose and strong justification on its own. Its purpose is not today's energy needs; it is aimed at the national energy needs of the future, where only the federal government can be expected to look to the national well-being. Its major purpose is the development of truly advanced civilian reactor systems with characteristics so demonstratively superior that essentially limitless nuclear energy for the first time becomes practical from every important point of view. It is my hope that in sharing with this Committee the recent progress on the IFR that it will become clear that in the past year the civilian program has made remarkable progress in this direction.

The goal of IFR development is a new reactor technology whose central element is fool-proof, fail-safe, inherent reactor safety -- inherent simply in the materials used in the reactor and specifically not dependent for ultimate safety on the performance of mechanical systems or human operators. We have made impressive progress on this in the past year. Landmark IFR

inherent safety tests were carried out on our EBR-II reactor on April 3rd of this year. They were spectacularly successful. Because of their importance I will describe them in detail in a few moments.

The events of this past week in the Soviet Union make the crucial importance of these tests dramatically evident. At this time one can only guess at the implications of the Soviet accident on future civilian nuclear power, but, at the very least, they make even more certain the need to emphasize civilian advanced reactor development that promises breakthrough improvements in reactor safety.

I should stress that the IFR is not just a new reactor design. It is an entire reactor system, based on new technology, and complete in every regard -- inherently safe reactor, radically new processes for fuel processing, fabrication, and waste management. It is in the R&D stage at Argonne National Laboratory. Development was initiated less than two years ago. As will be evident in the breadth and depth of the progress I am about to describe, IFR development has moved remarkably quickly from the idea stage to feasibility demonstration.

- The IFR uses a new simply-fabricated metallic fuel. A one-step fuel fabrication process has been perfected. Several hundred IFR prototypical fuel pins have been fabricated, and are under irradiation in EBR-II. The lead subassemblies have passed 50,000 MWd/T burnup, on their way to 100,000 MWd/T and higher. There have been no individual failures and no evidence to expect any.

- The IFR uses an extraordinarily compact revolutionary new pyroprocess for reprocessing fuel. The process involves just a single step for the fuel, and one more for the blanket material. Both steps have been demonstrated on lab-scale, R&D is continuing, and equipment is being designed for demonstration on plant-scale.

- The IFR will process, package and store its own waste. Our aim is process the waste so that the long-lived actinide radioisotopes are no longer present in anything but a small portion of the waste. Recent experiments have indicated probable feasibility.

- The IFR promises breakthroughs in the economics of the fuel cycle. Design studies have been completed that indicate fuel cycle costs as low or lower than the LWR, even at present day low uranium prices.

- The IFR concept is adaptable to a variety of designs. Argonne is working hand-in-hand with the industrial firms that are developing innovative LMR designs. My colleagues here this afternoon from Rockwell and General Electric will speak to their innovative LMR designs.

Most importantly in the light of the current events in the USSR, however, is the progress on inherent safety. On April 3rd, two safety tests of historic importance were conducted on EBR-II. Their purpose was to show that reactors of the IFR type are extraordinarily and inherently safe. Within

hours of each other, two potentially very severe accident situations were initiated while the reactor was operating at full power. In both events the plant simply shut itself down, harmlessly, without any action on the part of the plant operators or any action by the normal plant protection systems. And after each event, the reactor was left ready to be restored to full power operation in normal fashion. The possibility of reaching this level of invulnerability was undreamed-of even a few years ago.

These accident simulations were the most severe of their kind ever attempted in any reactor without damage of any kind. They dramatically demonstrated the powerful safety attributes provided by the IFR combination of liquid sodium cooling, pool reactor configuration, and metallic reactor fuel. No other reactor type that I am aware of could have survived accidents of this kind. And the EBR-II behavior is completely prototypical of IFRs in general. That is really the central point: The tests demonstrated not only that EBR-II is unharmed by such accidents, but more than that they demonstrated that no properly designed IFR of any size would be either. I think you will see how remarkable this is as I go on to describe just what these tests were.

The first accident sequence, conducted in the morning of April 3rd, was a direct simulation of the classicial postulated loss-of-flow without scram accident. With the plant operating at full power and with the plant protection system disabled, power to the primary, secondary and auxiliary pumps was turned off, just as though all off-site power had been lost ("station backout"). In effect the reactor continued to run in the absence of all forced cooling. Core coolant temperatures rose, generating negative reactivity which drove the power level close to zero without the assistance of any engineered safety features or operator action. After a brief rise, the coolant temperature returned to normal values, stabilized, and the reactor would have remained in this stable safe condition essentially forever. In fact the test was terminated after the stable condition had been established to prepare for the second accident simulation that afternoon.

The afternoon test was also a direct simulation of a classical postulated serious accident, this one of total loss-of-heat-sink without scram. In this test the reactor was returned to full power (five hours after the first test), the plant protection system again was disabled, and power to the secondary pumping system was turned off. (In some respects this test simulates the sequence of events that led to the TMI accident.) Since heat rejection capability no longer existed, inlet core coolant temperatures rose and again self-generated negative reactivity feedback drove the power to zero. The result was almost a non-event; the outlet coolant temperature actually decreased to a stable value less than the original operating temperature. Again, a safe stable condition was reached in a few minutes.

The inherent safety of the IFR is fundamentally due to the unique combination of the high heat conductivity of metallic fuel and the great thermal inertia of the large volume of relatively cool sodium in the pool. At no time in either event did the coolant come close to boiling, nor did any fuel approach the point of failure.

The tests were witnessed by about 60 representatives of the nuclear industry, electric utilities, and U.S. and foreign governments. The tests were spectacular demonstrations, or confirmations, of the complete invulnerability of the IFR to the two most plausible serious mechanical failures that could be postulated to happen in a nuclear power plant. In the simplest terms, we forced these accidents to occur, and the result was completely harmless.

But the entire promise of the IFR is as a self-contained civilian reactor system, complete in very regard. The development work is bringing along the complete system and the work should continue in this way. Further, as the EBR-II safety tests have demonstrated, nothing is as convincing as actual plant demonstration. The heart of any breeder system is its fuel cycle. This is particularly true of the IFR for it is in this area that the most revolutionary scientific advances are being made. The fuel cycle can also be demonstrated cheaply at plant-scale in EBR-II, and this has been our plan. I urge that the pyroprocessing development work continue, so as to lead to rapid demonstration in the EBR-II complex.

The Argonne LMR budget funds both our Idaho LMR facilities and our technology development effort including the IFR. About two-thirds is devoted to the facilities and one-third to the IFR and technology development. The President's budget sharply cuts the IFR and technology development. To maintain the IFR program and to move forward with the EBR-II IFR fuel cycle demonstration, Argonne is left in the position of needing a $19.3M increment for FY 1987 targeted specifically to the IFR.

In summary, Mister Chairman, I would like to make the following recommendations for the Committee's consideration.

1. The balance between civilian and defense advanced reactor development should be restored.

2. The precipitous decline in civilian reactor development support should be reversed.

3. The proper current focus of the civilian reactor program is an iteration between R&D and design on an advanced reactor system that specifically provides breakthrough-type characteristics. Current events only emphasize the certainty of the need for a high degree of inherent safety, probably only achievable by a new advanced reactor type based on new technology and principles.

4. The IFR concept is defined by such characteristics. IFR development has been extraordinarily successful to this point, and it should proceed, with the next major milestone the demonstration of the fuel cycle in the EBR-II complex.

Mister Chairman, I thank you for this opportunity to share my views with your Committee.

Senator DOMENICI. I thank you.

Could you just quickly tell me again what is the basic physics of that experimental facility and what its source of energy is?

Dr. TILL. Yes. The basis of the IFR is first sodium cooling that allows operation of the reactor at atmospheric pressure. That in turn allows a reactor configuration called a pool configuration, that gives a large heat sink of cooled sodium under accident situations.

The third element is a new metalic fuel that allows accident situations the power to drop very quickly, such that the overall coolant temperatures do not rise much.

Those are the three elements that give the safety characteristics. And the fourth element of the IFR is a revolutionary new fuel cycle concept, a reprocessing scheme that is done very simply with one step. It is radically new, and that in turn gives a fuel cycle possibility of having a fuel cycle that is, first, economic; second, contained within the plant; third, diversion resistant; and fourth, the possibility of providing the waste in a form that all the long-lived isotopes are removed from it and recycled through the reactor.

It is a whole concept, Mr. Chairman.

Senator DOMENICI. Thank you very much.

Mr. McDonald, Rockwell International.

STATEMENT OF JOHN McDONALD, DIVISION DIRECTOR, ATOMICS INTERNATIONAL SEGMENT OF ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL

Mr. MCDONALD. Thank you, Mr. Chairman. I appreciate the opportunity to address you today.

We at Rockwell are very concerned with the attrition in recent years of budgetary support for the U.S. Civilian Reactor Development Program, and we have seen more of that progress—or process taking place in the current recommended budget.

We therefore welcome this opportunity to express our views on this important subject. First I would like to briefly highlight the Rockwell background which qualifies us to comment on this issue.

Rockwell has been involved in nuclear technology development since the early 1950's, particularly in the design and construction of liquid metal reactors. We have produced and operated eight LMR's for terrestrial and space applications. We have also for many years been involved in the mainstream DOE liquid metal reactor program, and we have constructed and operated for about 20 years the world's largest facility for testing liquid metal reactor components, the DOE's Energy Technology Engineering Center.

Our systems have operated for well over 600,000 hours, and during this period there have been no injuries to personnel caused by liquid metals.

The DOE's advanced reactor program has been very successful in developing the technology for the next generation nuclear reactor, and Dr. Till's description is a good example of that. Rockwell's current main LMR thrust on this program is development of an innovative design, which we have named the sodium advanced fast reactor. The acronym is SAFR.

The SAFR team of Rockwell, Combustion Engineering, and Bechtel is producing a design which capitalizes on the favorable physi-

cal properties of sodium to provide solutions to historical concerns with light water reactors. The SAFR design and construction approach also offers promise to alleviate many of the institutional concerns which confront the electrical power industry.

The written testimony submitted for the record, along with an accompanying brochure, describe the SAFR approach in more detail, and I would like here to mention just a couple of noteworthy safety features which provide walk-away safety characteristics similar to those Dr. Till has just described which were demonstrated by EBR– II, and also similar to those that LMR overseas programs have shown.

The SAFR design has the inherent capability, based on the actions of natural forces, to shut down and maintain safe, stable reactor conditions under any credible circumstances without operator action or external power. Passive safety features are incorporated in the design, including redundant decay heat removal systems which operate by natural convection, a self-actuated core shutdown system, reactor self-regulating power-limiting feedback mechanisms, and the use of metal fuel further enhances the plant's safety characteristics.

It is not possible for SAFR to experience an accident of the type which occurred at TMI and more recently at Chernobyl.

With these features, the probabilistic risk assessment calculated for SAFR shows risks that are several orders of magnitude better than the NRC guidelines, and we believe that to earn public acceptance nuclear plants must represent such low risks.

The benefits of the advanced reactor development program are not limited to the civilian electric power industry. Following DOE guidance received earlier this year, we are exploring the possibility of utilizing SAFR for various potential military applications, and it does appear that there may be substantial synergisms between civilian and military reactors for certain SDI applications, such as ground-based lasers.

We are providing technical and economic data to the appropriate planners to aid their formulation of program plans for SDI ground-based power. Also, Rockwell is utilizing technology developed on the civilian reactor program and proposing a unique 10 megawatt electric LMR design for the multimegawatt terrestrial powerplant in the process of procurement for the Air Force.

And while these potential military applications are important, we must not lose sight of the great importance of maintaining the nuclear option for future civilian electrical power generation. According to a number of analysts, even with modest growth rates in electrical demand, a critical shortage of generating capacity will develop in the United States in the 1990's.

Environmentally clean, naturally safe and economically competitive central station plants will be needed. The DOE advanced Civilian Reactor Program is a significant source of the concept and technology improvements which can enable nuclear power to fulful its role in meeting, in helping meet the Nation's long-term energy needs.

However, the reduction of more than 60 percent in the advanced reactor R&D budget would be very damaging. This cut threatens a number of high priority activities, including further development

of the SAFR design and the related interaction with the utilities and the NRC, testing of SAFR cost reductions and safety design features, steam generator testing, further substantiation of the promising metal fuel option, as well as a long-life oxide fuel demonstration.

In conclusion, Rockwell believes that a liquid metal cooled reactor such as SAFR can in the future provide a safe, economic, and environmentally clean source of energy which will be acceptable to the utility industry, the financial community, and to the general public.

The liquid metal reactor has been the clear choice of the industrial nations of the world for the next generation reactor, and it would be a serious mistake to deny the advantages of this technology to the country that invented it.

To preserve this option for improved advanced reactors and to provide a bridge, a technology bridge, to the Nation's long-term needs for breeder reactors, a stable, adequately funded program is necessary to allow continue close interaction with potential users and the NRC, ultimately leading to certification of an advanced liquid metal reactor such as SAFR.

And that completes my prepared statement, Mr. Chairman.

[The prepared statement of Mr. McDonald follows:]

TESTIMONY OF JOHN MC DONALD
DIVISION DIRECTOR, ATOMICS INTERNATIONAL

SENATE ENERGY RESEARCH AND DEVELOPMENT SUBCOMMITTEE HEARINGS
ON ADVANCED REACTOR PROGRAMS

Mr. chairman, members of the committee, thank you for providing the opportunity to address you today. I am John McDonald, Director of the Atomics International Segment of Rockwell International's Rocketdyne Division. As a leader in advanced reactor development, Rockwell has had the privilege of addressing this and other subcommittees many times in the past regarding the U.S. DOE Advanced Reactor Program. We are very concerned with the attrition in recent years of budgetary support for the U.S. civilian reactor development program, and the result and impact on long-term national energy security and the U.S. nuclear option. We therefore welcome this opportunity to express to you our views on this important subject.

Before commenting on this central subject, I would like to briefly highlight the Rockwell background which enables us to comment on this important issue. Rockwell has been involved in nuclear technology development since the early 1950s, particularly, in the design and operation of liquid metal-cooled reactors (LMRs).

Our experience in the LMR field includes the pioneering research, development, design, construction, and operation of eight liquid metal-cooled reactors for terrestrial and space applications; and a major role in the U.S. Liquid Metal Fast Breeder Reactor Program since its inception.

Rockwell designed, built, and has operated for 20 years the world's largest facility for testing liquid metal reactor components--the DOE's Energy Technology Engineering Center (ETEC). During this period, there have been no injuries to personnel caused by liquid metals, which demonstrates the safety of sodium systems. ETEC has a wide range of capabilities for component testing, including endurance testing of steam generators, seismic load testing of full-scale pipe mockups, convective core cooling system testing, and high-vacuum testing of liquid metal systems for space reactors. The most significant current program is the planned endurance testing of steam generators for LMRs. Steam generators are perhaps the single component most critical to nuclear plant reliability and availability. The LMR steam generators will be tested in a cogenerative facility in which the generated steam will drive a turbine and produce revenue from electrical power sales, thus offsetting part of the cost resulting in a very economical test program. A more detailed description of ETEC is attached to this testimony.

Our current main LMR thrust on the DOE civilian reactor program is development of a next generation power plant design which we have named the Sodium

Advanced Fast Reactor (SAFR). The SAFR team of Rockwell, Combustion Engineering, and Bechtel is producing an innovative design which capitalizes on the favorable physical properties of sodium to provide solutions to historical concerns with light-water reactors. The SAFR design and construction approach also offers a promising basis for alleviating many of the institutional concerns which currently confront the electrical power industry. SAFR is being designed from the ground up to meet the needs of electric utilities, and we review the design regularly with these organizations. Attached to this testimony is a summary of these institutional concerns, along with a list of some of the valuable advantages which SAFR can offer utilities.

The need to develop the nuclear power option will not go away. According to a number of analysts, even with modest growth rates in electrical demand, a critical shortage of generating capacity will develop in the U.S. in the 1990s. Further, in the future, utilities will need environmentally clean, naturally safe, and economically competitive central station power plants. In some areas of the country, the nuclear option will become a must since burning coal and high sulfur (Alaskan) oil to generate power would exacerbate air pollution problems. This provides added emphasis to maintaining the effort in the Advanced Reactor Program.

The DOE's Advanced Reactor Program has been very successful in developing the technology for the next generation nuclear reactor. This technology has been translated into many advantageous characteristics which set the SAFR design apart from others. The SAFR plant employs a standardized 350-MWe liquid-metal reactor as its basic module. Such modules can be added at a given site to closely match increases in load requirements. The reactor will be factory-fabricated and barge-shipped to the site, thus maximizing quality and minimizing the time spent in field construction. Independently verified analyses indicate that mature SAFR plants should have lower energy costs than other plant types. In addition, with only minor modifications to the core, SAFR could be turned into a breeder reactor at any time. This low-cost breeder option would allow the U.S. to take advantage of the nearly infinite energy supply available through the plutonium fuel cycle.

The SAFR plant design and performance characteristics are described in more detail in the brochures submitted with this testimony, and I will limit the discussion here to the mention of several noteworthy safety features which provide the "walk-away" safety characteristics which have been demonstrated by EBR-II and LMRs overseas.

The SAFR design achieves a lower level of risk than current power plants. SAFR has the inherent capability, based on the actions of natural forces, to shut down or limit reactor power and assure adequate core and spent fuel cooling at all times without operation or external power of support systems. It is not possible for SAFR to have a TMI-type accident nor an accident of the type which recently occurred to a reactor in the Soviet Union. In addition, passive safety features incorporated in the pool-type design include redundant decay heat removal systems which operate by natural convection, a

self-actuated core shutdown system, and reactor self-regulating behavior which maintains safe, stable reactor conditions under any credible condition. With these features, the SAFR Probabilistic Risk Assessment, calculated in accordance with the U.S. Government Standard NUREG/CR-2300, shows safety risks several orders of magnitude better than Nuclear Regulatory Commission guidelines. We believe that to earn public acceptance, nuclear plants must represent such low risks.

The SAFR design is being reviewed in some detail with the Nuclear Regulatory Commission through a series of DOE-sponsored meetings. These discussions are of significant value in helping to assure that the evolving SAFR design will be licensable. This very important part of the development process must be continued if the advanced reactor development program is to be a success. We believe that established licensability is a prerequisite to major financial involvement of the private sector in the program.

In addition to the engineering effort of the SAFR team, development and test work supportive of SAFR is also proceeding at five National Laboratories in parallel with our design effort.

The successful introduction of an improved reactor technology into the marketplace will require that a large variety of institutional concerns be resolved. To assist us in grappling with these problems, Rockwell formed what we refer to as the Institutional Advisory Committee (IAC), which includes recognized leaders in the utility industry, the legal and financial communities, and media and public relations organizations. Many valuable suggestions and ideas have emerged from the meetings we have had with this group. They, along with our team members, are very enthusiastic about the concept and the program results to date.

The benefits of the advanced reactor development program are not limited to the electric utility industry. Pursuant to guidance received from DOE earlier this year, we are exploring the possibility of utilizing the advantages of the SAFR's versatility, safety, and "user-friendly" operating characteristics for various potential military applications. The defense sector requirements for ground-based power are still being defined. However, it appears that certain elements of the Strategic Defense Initiative (SDI), such as ground-based lasers, would require large amounts of secure power in quantities that could be provided by one or more SAFR modules. We are providing SAFR technical and economic data to appropriate DOD and military planners to aid their evaluation of power options and formulation of SDI program plans.

Technology spinoff from the civilian reactor development program has led to a smaller military power application concept. The Multimegawatt Terrestrial Power plant for which DOE has requested proposals is another example of reactor technology synergism between military and civilian applications. Rockwell is utilizing technology developed and proven on the LMR civilian reactor program in proposing a unique 10-MWe LMR design which offers the user a number of valuable technical advantages.

While both of these potential military applications of nuclear power are important, we must not lose sight of the tremendous importance of maintaining the nuclear option for future electrical power generation. As I have said, this need is heightened by the expected demand for significant new electrical generating capacity in the 1990s, and the environmental and economic uncertainties of fossil fuel power plants. Nuclear plant technical improvements, such as those offered by the SAFR, are needed to drive the institutional changes necessary for the nuclear option to regain viability.

The DOE advanced civilian reactor program is a major source of the concept and technology improvements which can enable nuclear power to fulfill its role in helping meet the nation's long-term energy needs. However, the reduction of more than 60% in the Advanced Reactor R&D budget is severe and it will be very damaging to this extremely important national program. This cut threatens a number of high priority activities, including further development of the SAFR design and related interaction with utilities and the NRC, test substantiation of cost reduction and safety features, steam generator endurance testing, further substantiation of the promising metal fuel option, and long-life oxide fuel demonstration. The current environment and market outlook is such that the private sector is very unlikely to step in with major funding for the development of advanced reactors. In considering this budget reduction, we strongly agree with recent statements by the Advanced Reactor Development Subpanel of the Energy Research Advisory Board's Civilian Nuclear Power Panel Draft Report (Reference 1) from which I quote:

> "The current Department of Energy (DOE) advanced reactor program is in danger of being totally eviscerated by the cutbacks being proposed in government funding of this important work."
>
> "In our opinion, pursuit of this course of action would be a serious and irrevocable mistake. Meaningful research simply cannot be conducted in an environment of on-again, off-again funding. This nation's investment in nuclear power is too great and its past and future contributions too significant to allow liquidation of four decades of advanced reactor R&D by default. Billions of dollars of consumer savings in addition to billions of dollars of export sales and thousands of high technology jobs for U.S. workers are at stake."

In conclusion, Rockwell believes that liquid metal-cooled reactors such as SAFR can provide a safe, economic and environmentally clean source of energy which will be acceptable to the utility industry, the financial community, and to the general public when it is needed in the next decade and beyond. The liquid-metal reactor has been the clear choice or industrial nations of the world (e.g., France, Japan) for the next generation reactor. It could be a serious mistake to deny the advantages of this technology to the country that invented it. To preserve this option for improved, advanced reactors, a stable, adequately funded program is needed to continue close interaction with potential users and the NRC, ultimately leading to certification of an advanced liquid-metal reactor design such as SAFR. This will provide an option for utilities in the near term and a technology bridge to the nation's long-term need for breeder reactors.

REFERENCES

(1) Draft Executive Summary of the Advanced Reactor Development Subpanel Report of the Energy Research Advisory Board's Civilian Nuclear Power Panel, February 1986

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ATTACHMENT 1

ENERGY TECHNOLOGY ENGINEERING CENTER (ETEC)

The Energy Technology Engineering Center, ETEC, is the Department of Energy's test site and center of excellence for high-temperature liquid metal components and technology. ETEC is performing high-priority work this budget cycle in demonstrating the capability of key LMR components, in proving design concepts for plant cost reductions and safety-related decay-heat removal systems. Planned testing also includes key components for space power units.

The evaluation of steam generators in all performance modes, and for long durations may be the single most important step in establishing the commercial feasibility of LMRs. The Sodium Component Test Installation at ETEC is the only facility where all steam generator operating modes can be tested effectively and economically. One test in FY 1987 will be the Babcock and Wilcox helical tube model steam generator. Performance testing at power levels up to 70 MWt, the world's largest testing capability, will be accomplished. During FY 1987, testing will be halted for addition of the Power Pak Cogeneration system. This system will be financed by private capital. When operational in 1988, the Power Pak will use the superheated steam generated in testing steam generators to drive a steam turbine and will produce revenue from electrical power sale. Vital long-term endurance testing data for steam generators will be acquired, and the cost of testing will be offset by the electrical power revenues.

The Fragility Test Facility at ETEC has the unique capability of imparting high-magnitude seismic loadings to complex piping system configurations representative of nuclear plant process systems. Testing in FY 1986 of 3-in. and 6-in. piping systems demonstrated the value of this type of testing for quantifying the conservatism of present seismic design codes for nuclear plants. Additional tests are planned in FY 1987. Nuclear plant design, construction, and operation will be simplified through the generation of fragility data vis-a-vis today's design codes. This means lower cost and greater certainty of the adequacy of design.

Safety in the operation of reactors will be greatly enhanced by passive shutdown heat removal systems. Testing at ETEC in FY 1987 is aimed at demonstration of key features of passive heat removal systems for the Innovative LMR plant designs. A test of a model of the SAFR design reactor air cooling system (RACS) is planned in the facility where testing of another SAFR concept for decay heat removal is being completed in FY 1986. Following the RACS test, a simple modification in the test setup will facilitate testing features of the General Electric PRISM design reactor vessel air cooling system (RVACS).

Operation of the high-vacuum SPACE facility at ETEC is planned for FY 1987. This facility will demonstrate the quality and reliability of critical components, for example, electromagnetic pumps and heat exchangers for service in 2,000°F liquid lithium systems, are made of refractory metals which

require an extremely high vacuum environment to protect against even minute quantities of oxygen during their exposure at the high temperature. The testing capability at the ETEC high-vacuum facility provides a unique resource for testing key SP-100 components and for supporting the Multimegawatt Program as well.

All future nuclear systems, whether for commercial power or defense, require component testing. The facilities, the staff, and the processes to do these tests are all in place at ETEC and no other facility or combination of facilities can match ETEC's component testing assets. ETEC operates very economically, staffs only those facilities that are in active use, and constantly seeks to reduce costs through innovative approaches such as the cogeneration project. At ETEC, each mode of operation is goal oriented; each program has a start, a finish, a schedule, a budget, and an expected output.

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ATTACHMENT 2

TYPICAL UTILITY CONCERNS

Stockholder risk
Public acceptance
Overall complexity, regulatory demand, investment required for nuclear plants
Uncertainties in adding large capacity increments to meet predicted load growth
Public utility approval on capacity and CWIP in rate base
Financing requirements
Construction uncertainties
Shared ownership risks
Risk of adopting different reactor type
Need for diversification of fuel sources.

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ATTACHMENT 3

SAFR PROVIDES UNIQUE SOLUTIONS TO HISTORICAL
LIGHT WATER REACTOR PLANT CONCERNS

Safety

No loss of coolant accidents

No possibility of fuel melting

No requirement for evacuation plan

Assured shutdown and decay heat removal independent of operator action or external power

Low pressure highly subcooled coolant

Potential for radioactive spills essentially eliminated.

Operations

Far fewer engineered safety and auxiliary systems--eliminates many potential failure modes

Very few trip signals to trigger shutdowns

Insensitive to TMI-type feedwater problems

Very low personnel radiation exposures

Minimal radwaste generated

Long life fuel and fast refueling.

Economics

Low generating cost

Limited cash outlay before power generation

Minimum safety envelope reduces capital cost

Shop fabrication and standardized design to simplify licensing and reduce construction uncertainties

Field construction schedule less than 3 years

Inherent safety protects capital investment.

0144U/ljm

Senator DOMENICI. Thank you very much.

Dr. Till, did you have additional remarks that I did not make part of the record?

Dr. TILL. No.

Senator DOMENICI. You did not have a longer prepared statement?

Dr. TILL. I have a longer prepared statement, Mr. Chairman.

Senator DOMENICI. It will be made part of the record.

Dr. TILL. Thank you very much.

Senator DOMENICI. Dr. Armijo, General Electric.

STATEMENT OF DR. JOSEPH S. ARMIJO, MANAGER, NUCLEAR SYSTEMS TECHNOLOGY OPERATION, GENERAL ELECTRIC CO.

Dr. ARMIJO. My name is Sam Armijo. I am manager of General Electric's Nuclear Systems Technology Operation. I also would like to thank the subcommittee for its invitation to participate in these important hearings. My remarks will focus on the Department of Energy's Civilian Reactor Program.

We believe there are two principal goals to be achieved by the program: Assurance of U.S. energy security for the long term; and the expeditious revival of the U.S. nuclear option.

Achievement of the short term goal requires the use of the light water reactor, and the long term goal can best be satisfied with liquid metal reactor technology and the breeder. The LWR and LMR goals are complementary and both should be pursued.

I have covered the rationale and approach to these goals in my written statement, and request that the statement be included in the record. Today I will limit my remarks to two programs that can provide major near-term progress for meeting these goals.

First, I want to voice our support for the light water reactor program that DOE, in conjunction with the Electric Power Research Institute, has proposed for fiscal year 1987. An aggressive effort toward design verification of an advanced light water reactor can achieve results that reopen the U.S. nuclear option within 5 years.

We and others have made great progress on advanced light water reactor design in cooperation with our overseas associates, and these designs are available for this U.S. effort.

Now I would like to address the issue of the future of the liquid metal reactor, or LMR, program. The innovative LMR program can address technical, economic, public, and political concerns through technological innovations and proof of passive safety in a full scale reactor test.

Currently we are under contract with DOE for a comprehensive assessment of our modular liquid metal reactor concept, which we call PRISM, and that stands for Power Reactor Inherently Safe Module. Rockwell International is pursuing a competing concept.

Completion of these 3-year programs was scheduled for fiscal year 1987 with a fiscal year 1987 program cost of $19.3 million. The purpose of this effort is to determine if there is a technically and economically realistic solution to the unfavorable economics and very high demonstration costs of large liquid metal reactor plants.

We believe the results of DOE's innovative LMR program are vital for effective program guidance and urge the subcommittee to

provide the contract funds for completion of this work as planned. This effort should receive top priority in the LMR and breeder program since it is critical to the commercial application of the program's substantial technology investment and output.

We are encouraged with the progress of the modular reactor concept. We believe this technology offers a unique potential for a fully self-protecting LMR. The recent tests that Mr. Till reported at EBR-II have demonstrated the technical feasibility of this passive safety approach.

Since our PRISM reactor concept is a small pool reactor, it can be tested full scale and at moderate cost, and thus provide the basis for major reduction of regulatory constraints that have contributed to the high cost of large monolithic systems.

With regulatory controls limited to a smaller portion of the plant, modular LMR's should have scaling—that is, cost-scaling—characteristics similar to fossil plants, which show only a minor cost penalty with small unit sizes. Application of standard certified units of this type would greatly reduce utility financing risks and provide the flexibility to economically serve a wide range of load growth requirements.

While the results to date of this program are promising, they are incomplete and cannot be concluded with the proposed DOE funding for 1987 of $6 million. However, with the originally planned effort we can deliver technical and economic assessments with sufficient depth to judge how this technology would fare in the marketplace. We will also be able to present a definitive plan for proceeding toward commercialization.

Proceeding with the innovative LMR program is particularly important for its potential of demonstrating a fully self-protecting reactor assembly. As noted earlier, we have taken this approach to overcome the economic obstacles facing the LMR.

Our approach has included and continues to include a reactor test that would full demonstrate the inability of external events to cause an excessive radiation release or even damage to the reactor assembly. In view of the events of the last 10 days, this type of demonstration is extremely important in our opinion for advanced LMR systems.

In closing, the two issues I have addressed involve relatively modest resources, but will provide near-term conclusions and guidance for future direction of the program.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Armijo follows:]

STATEMENT OF

JOSEPH S. ARMIJO
MANAGER
NUCLEAR SYSTEMS TECHNOLOGY OPERATION
GENERAL ELECTRIC COMPANY

ON

CIVILIAN REACTOR PROGRAMS

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH & DEVELOPMENT
SENATE ENERGY & NATURAL RESOURCES COMMITTEE

MAY 5, 1986

My name is Joseph S. Armijo. I am Manager of General Electric's Nuclear Systems Technology Operation. I want to thank the subcommittee for your invitation to participate in these important hearings and will direct my statement to possible developments that could aid nuclear power in the future in the U.S.

PRINCIPAL GOALS

We believe there are two principal goals to be addressed in the DOE Civilian Reactor Program.

1. A focused program that assures U.S. energy security for the long term, and to this end
2. Revival of the U.S. nuclear option on an expeditious basis.

A favorable solution to the short term goal implies the use of the light water reactor.

The long term goal can be satisfied with Liquid Metal Reactor (LMR) technology and the breeder. The LWR and LMR goals are complimentary. A resumption of U.S. LWR orders will act as a constraint on fossil fuel prices and increase the commitment of uranium resources. Development of a U.S. LMR option will in the long run limit potential uranium price increases resulting from the expanded use of LWRs while providing a means for regaining U.S. nuclear leadership and influence in international nuclear policy. Both goals can and should be pursued.

For the future we should also consider the High Temperature Gas Reactor (HTGR) technology for the ultimate purpose of providing an alternative to the fossil production of industrial process heat, thus allowing nuclear power to further contribute to the national well being.

PROCESS AND RESPONSIBILITIES

While there are many specific constraints to a viable U.S. nuclear option the most significant are institutional factors beyond the control of the private sector. To be more specific, the existing U.S. regulatory practices and procedures controlling the environment for construction of nuclear plants make their schedules too long, their cost too high, and their unpredicability too great.

General Electric supports legislative reforms in the licensing of nuclear plants. We support one step licensing, limits to backfitting and pre-approval of sites. To be successful, these reforms require a standardized design entailing very large investments before it is clear that an environment necessary for successful nuclear power deployment has returned.

We believe the Federal Government through the DOE should fulfill its responsibility in the current nuclear hiatus by providing a program that assures that nuclear power plants can be designed, constructed and operated in a reasonable and predictable environment in the U.S. Independent of the technology, key to this assurance is the final NRC certification of a plant design. The DOE program should be directed towards developing and proving designs with features that can reduce regulatory scope over the plant design, construction and operation. For this effort to be successful each reactor design effort must define the approach to meeting regulatory requirements that will allow sufficient freedom in the plant's construction and operation to control the excessive costs associated with recent U.S. nuclear plants. It

must also define developments, analyses and demonstrations that will be necessary to achieve these goals. The DOE should carry out the specified program, at least to the point where there is NRC certification and an assurance of a reasonable U.S. environment to accept the risk of proceeding with new nuclear projects. Other institutional constraints such as financing and public acceptance will follow if we can gain control over the cost and schedules of our plants.

Proposed LWR Programs

We believe that the Government can help restore the LWR option in the U.S. by concentrating support in two areas - licensing of the Advanced LWRs and advancement of the mid-size LWR program.

Current U.S. licensing has large uncertainties for utilities that might be contemplating nuclear additions and our own experience with the GE Standard Safety Analysis Report (GESSAR) has not been good. We have been in favor of standardization from the beginning, and were the first to pursue a license for a standard BWR in 1973. However, continued changes in NRC rules leave us 13 years later still pursuing certification, after the expenditure of tens of millions of dollars in the licensing process alone. Our experience is by no means unique.

Government sponsorship of NRC certification of Advanced LWR designs will provide the proof that institutional reform has really taken place and restore confidence in the licensing process. The process we see is as follows:

- An Electric Power Research Institute (EPRI) requirements program is in progress and will provide the Advanced LWR requirements.
- Industry will provide the Advanced LWR designs which meet those requirements. In our case, the ABWR design developed jointly by GE and its Japanese associates represents an investment in excess of $200 million.
- The Government provides a program that results in NRC certification. This includes both final design approval and the public hearing process leading to certification. It also includes any supporting effort that may be required to realize a rational certification through these processes.

A second way in which the Government can help the LWR option is through support of the mid-size LWR program. If successful, this program will permit economic nuclear deployment in smaller increments therefore at lower financial risks. The EPRI has initiated a modest conceptual study of mid-size LWRs with the primary objective of being cost-competitive with coal; employing passive safety features to the maximum extent possible, thus minimizing the safety envelope for review. This is viewed as a way to overcome the traditional scaling penalties associated with the smaller nuclear unit sizes. We are very encouraged at the results to date, which may be applicable not only in the U.S. and may also permit us to exercise leadership abroad. We believe a modest test and assessment program is appropriate to determine the potential of the mid-size concept. How industry would proceed beyond this to a final design and certification will depend not only on the test results but also on U.S. need and the environment for nuclear at the conclusion of the mid-size concept assessment.

The type of program I have outlined can be completed and produce definitive results within a five year period and I believe could go far toward meeting the critical goal of reviving the nuclear option in the United States.

Advanced Reactors

The Advanced Reactor Subpanel Report of the Energy Resources Advisory Board (ERAB) has recommended three key goals for advanced reactors.

1. Timely development of an efficient and economically superior advanced reactor system for application on the nation's electric power systems, building on the vast base of LWR experience and the knowledge gained from 40 years of applied R&D, both here and overseas.

2. Maintenance of U.S. influence in international policy-making concerning civilian nuclear power and non-proliferation by remaining in the vanguard of advanced reactor R&D and sharing on appropriate bases the generic results with the rest of the world.

3. Maintenance of the U.S. as a competitive supplier of nuclear power systems to the world markets by assisting the U.S. industrial community in development of superior proprietary designs, products, and skills through transfer of technology from its advanced R&D program.

Proceeding toward these goals provides an opportunity for the U.S. to act so as to help maintain our non-proliferation objectives while helping our friends and becoming leaders in the attempt to develop an energy secure world. The opportunity arises because present breeder development programs outside the United States may be going down the wrong track. The developmental breeders already built and being built today are technically successful, but are so costly as to be economically impractical. The plans abroad are to serially build additional large multi-billion dollar plants with the hope that the experience gained will ultimately lead to an economically practical plant. But each plant costs billions of dollars and takes of the order of a decade to put into operation. It is not clear that the process will converge. Indeed, in Japan high costs have led to a slowdown in the program, and in Europe where the high costs have dictated a multi-nation approach it has been difficult to reach agreements on the next proposed plant.

In recognition of this situation the Department of Energy program has been investigating a new approach to breeder development. The idea is to look at small sized units of the order of 100 to 300 megawatts which can be joined in arrays to form large plants. Because of their small size the "modular" units can have the advantage of shop fabrication. In addition, the small size permits fail safe emergency cooling systems which are independent of the balance of plant outside of the modules. The balance of plant can therefore be constructed to high quality industrial standards, rather than to the astronomically expensive nuclear safety standards. Further, because of the small size a demonstration module is relatively inexpensive to build. Once it is built, tested, and licensed as a result of the demonstration test, the module becomes the actual building block for the commercial plants.

We are encouraged with the progress of the modular reactor concept. We believe this technology offers a unique potential for a fully self protecting reactor assembly. This in turn can provide the basis for major reduction of institutional constraints that have led to the current high costs of the large monolithic systems. With regulatory controls limited to a smaller portion of the plant, nuclear plants should have scaling factors more like fossil plants which show only a minor cost penalty with small capacity levels. This would then open the opportunity for unit sizes that greatly reduce financial risks and provide the utilities with the ability to economically meet their load growth patterns.

In view of this promise, we believe the modular reactor development should be maintained and expanded when appropriate. Limited studies will never provide the degree of confidence necessary to proceed with commercialization of this concept.

Only with a final design and regulatory certification will it be possible to assure such a concept can realize their full potential.

With future constraints on funding expected we believe it important to proceed with such a focused advanced reactor program. If there is any one lesson we should have learned from our past nuclear experience, it is that basic technology without the generally larger and higher risk effort of integration into specific proven designs does not lead to the development of viable plants to meet our electrical needs. Therefore the development programs should concentrate on developing economic plant designs, with the technology programs providing only the critical information necessary to carry out the design.

Our planning shows development, design, construction and operation of a modular reactor assembly test could be completed in about 8 years for a total cost of about 600 million dollars. This effort would provide the basis for a final regulatory certification of the assembly. The program would be expected to prove the reactor assembly's self-protection features and provide the public and political confidence that will be necessary for limiting regulatory control to the reactor assembly and fuel handling facilities of the plant. It would also provide the confidence that plant cost estimates are predictable and can be reasonably assured.

There are, of course, risks in such a venture. As indicated earlier, the economics of the modular approaches are primarily based on constructing a standardized modular plant with practices and procedures more like a fossil plant than those of today's nuclear plants. Studies by our Power Reactor Inherently Safe Module (PRISM) team have shown the cost of vendor supplied components and materials are essentially equal for the average U.S. nuclear and coal plant. However, the site field labor for the average nuclear plant exceeds that for a coal plant by a factor of two and the indirect site labor costs are five times higher. While standardization and experience can reduce the differences, less regulatory control of the construction process is necessary to reduce the cost of the construction process to a level that would make the modular system fully competitive. We do not believe studies or technology developments, regardless of how promising, can assure this one basic goal can be realized but it may be possible to gain this assurance through a successful full scale reactor assembly test. Therefore, we propose that the commitment be made to proceed with a reactor test of the most promising concept and reach a conclusion through final regulatory certification.

International Cooperation

We believe it is possible to gain overseas participation in the development and proof of our modular innovative concepts. The overseas development of new large monolithic systems has proven to be extremely expensive and none has proven to be economically competitive. Therefore we have found a growing overseas interest in our PRISM concept. A selection and firm commitment to a reactor test could bring about a major overseas participation in such projects. We have in the past enjoyed overseas participation in our developments and can likely regain this advantage with a firm commitment to a promising concept.

I should also emphasize the great importance of such a program to our foreign policy non-proliferation objectives. We presently have the self inflicted situation of trying to address the proliferation issue by threatening an embargo on export of U.S. technology to non-cooperating nations, while at the same time slowing the progress of nuclear energy in this country. There is presently a worldwide surplus of supply capacity in every phase of nuclear power. What is it that we will embargo if present trends continue and we lose technological leadership? The suggested program described above can lead not only to increased well-being in the U.S. due to

assurance of energy supply; but also to worldwide well-being as the U.S. is able to maintain its constructive nuclear technological leadership on an international basis; and to influence developments in ways which reduce the threat of spread of nuclear weapons.

CONCLUSIONS

Proceeding with a focused program toward revival of the LWR option should be our highest priority. In a competitive world the U.S. is one of the few countries which denies itself the use of low cost nuclear power. The need is evident. A nuclear option provides competition and a choice for the utilities when they begin replacing their aging capacity and satisfying the current growth in demand. The action is clear. Prove through a binding regulatory certification that our advanced LWR plants can be constructed and operated in the United States under conditions that permit standardization and reduces the uncertainty associated with our current plants. The cost is modest. New final advanced designs exist through our cooperative efforts with our overseas partners so we can proceed directly with their certification. And we have in place, the industrial infrastructure necessary to provide this option when it is clear we have an environment more conducive to the acceptance of nuclear power.

Proceeding with a balanced advanced reactors program will likely require some critical and difficult decisions. A comprehensive program would include continuation of our base technology developments and proceeding toward the final design and certification of our current innovative reactor concepts. For the LMR, it also includes closing the fuel cycle if we are to realize the full potential of this technology. We believe it would be in the nation's best interest to carry out a comprehensive program, but the current FY86 budget is not sufficient to carry out such a program and the proposed FY87 budget appears to demand further limits to the advanced reactors program.

We now face the possibility that maintaining the expensive technology and fuel development programs and facilities will leave the Advanced Reactors Program with insufficient resources to carry out the most important mission, advanced reactor development. Therefore, we urge the Committee to address this issue and provide guidance on priorities for the advanced reactor program. While we recognize the value of our base technology developments, we do not believe fuel developments deserve our top priority. We, as well as other countries, have sufficient oxide fuel operating experience today. All countries, however, are struggling to reduce plant costs. This is where the problem is, this is where the U.S. program has a lead, and this is where we should focus our resources.

Senator Domenici. Thank you very much, Dr. Armijo.

Dr. Arnold, Westinghouse Advanced Energy Systems, you are our last witness. We are delighted to have you here.

STATEMENT OF DR. W.H. ARNOLD, GENERAL MANAGER, ADVANCED ENERGY SYSTEMS DIVISION, WESTINGHOUSE ELECTRIC CORP.

Dr. ARNOLD. Thank you, Mr. Chairman.

I appreciate this opportunity to comment on DOE's civilian reactor development program. Since joining Westinghouse in 1955, I have been personally involved in technical and management positions in our pressurized water reactor programs, both domestic and international, in the NERVA program for development of compact gas reactors for nuclear rockets, and in our liquid metal reactor development programs.

I will concentrate my remarks today on the liquid metal reactor, although my prepared testimony, which I also submit for the record, also addresses light water reactors and supports strongly DOE's current initiatives in the light water reactor.

Of course, the light water reactor option must remain viable before there will be a need for advanced reactors of any type. Assuming that, the rationale for the breeder still holds on the basis that uranium is a finite resource. The world choice for nuclear power generation in the long term is clearly liquid metal fast breeder reactor.

There are currently 14 of these in operation, under construction, or in design around the world, and nearly 3,000 megawatts of electricity are being produced by them. The most successful of these programs is in France, where the Phoenix reactor has been producing electricity since 1972. In January of this year, the 1,000 megawatt electric Super-Phoenix reactor also began producing power to the European grid, and is expected to be operating at full power by mid-1986.

This is a major achievement, attained through the collaboration of various European governments, utilities, and manufacturers in a focused program.

The U.S. program has also been successful. EBR–II, on which we have just heard some remarkable tests, has been in operation since 1964, and the fast flux test facility, FFTF, has been operating since 1980. In 1985, FFTF achieved a capacity factor of 71 percent, also truly remarkable for a test reactor that is carrying out a complex experimental mission.

Operating experience gained at FFTF is available to apply to the next generation liquid metal reactors in areas of both safety and economics. The major technical challenge for breeder development is achieving a reduction in capital costs to reach economic parity with other generating sources, while maintaining the highest level of safety.

It is our opinion at Westinghouse that this difficult cost target can be met by the time breeders are required. We are currently working under DOE contract, in cooperation with Mitsubishi Heavy Industries of Japan and independently owned corporate funds, to achieve these objectives. Among the innovations we are

developing are the significant economies associated with inherent safety and the use of long-life cores, especially with oxide cores where we have the experience base.

Advances in inherent safety capability and in the burnup capability of oxide fuel permit new design approaches for liquid metal reactors. These can be designed to operate for ten years or more without refueling. They are more efficient users of our fuel resources and can be started with uranium fuel.

Plutonium is formed and burned in place. It need not be reprocessed or handled.

The potential for long-life cores is great, as was recognized by the Energy Research Advisory Board Subpanel on Advanced Reactors, which rated further development of long-life cores as one of the highest priority areas. Yet, the DOE-proposed liquid metal reactor development budget for fiscal year 1987 allocates less than one percent to this area. I think this is an area that clearly deserves more emphasis in DOE's program.

Inherent safety testing in FFTF is also vital because it will demonstrate that passive design features, relying just on the laws of nature, are effective in terminating off-normal conditions. Proof testing these systems in an instrumented LMR environment under controlled conditions is an important step in the development of inherently safe designs.

In summary, we believe that the advanced reactor program should focus on a liquid metal reactor based on these initiatives, because: First, it will result in a safe, simple reactor that has potential to compete economically with other electrical energy sources; second, it can use enriched uranium dioxide fuel, so that no new fabrication plants are required; third, it makes and uses plutonium as it operates, so reprocessing is not required. Since the plutonium is not separated, it is free from proliferation concerns; fourth, less waste results because fewer assemblies are discharged with a long-life core; fifth, the major program assets, such as EBR-II and FFTF, are already in place.

And finally, since the plant technology does not change, a very straightforward transition to breeding can be made when the need arrives.

Thank you, Mr. Chairman, for the opportunity to provide our views.

[The prepared statement of Dr. Arnold follows:]

Testimony

to

Senate Committee on Energy and Natural Resorces

Subcommittee on Energy Research and Development

May 5, 1986

Dr. W. H. Arnold, General Manager
Advanced Energy Systems Division
Westinghouse Electric Corporation
Madison, Pa. 15663

I am Howard Arnold, General Manager of the Advanced Energy Systems Division of the Westinghouse Electric Corporation. Since joining Westinghouse in 1955, I have been personally involved in technical and management positions in our PWR reactor programs both domestic and international, our NERVA program for development of compact gas reactors for nuclear rockets, and our liquid metal reactor development programs. At the Advanced Energy Systems Division, we are designing and developing advanced reactors - liquid metal, light water, and gas cooled - for terrestial and space applications.

I welcome this opportunity to testify on the need for the DOE civilian reactor development program and the issues this program must address. Westinghouse has also participated in the review of the program by the Energy Research and Advisory Board.

I will concentrate my remarks today on the LWR and the Liquid Metal Reactor (LMR).

Need for Restoration of LWR and Realization of its Potential

I will begin by reviewing the importance to the nation of the restoration of the LWR and full realization of its potential. Nuclear generated electricity is essential to the energy security and economic well-being of our society. It is a technology the United States cannot afford to lose and the LWR must be restored as a first priority; otherwise, there is no logical basis for an

advanced reactor program. There are now 374 nuclear plants operating in 26 countries worldwide, producing approximately 15% of the world's electricity.

European and Far East nations have large and expanding nuclear electricity programs, based in large part on the LWR technology and designs developed in the United States. The 98 plants in the U.S. produced 15% of our electricity in 1985, but there have been no new orders since 1978. Two major studies carried out in 1985 by the Edison Electric Institute and the Atomic Industrial Forum found a general consensus that there will not be another domestic nuclear plant order under current conditions. We believe that the ERAB review of the DOE civilian reactor program will reinforce these conclusions. In particular, there is strong conviction from these reviews that the arduous Federal regulatory process has become a major component of the institutional impediment to nuclear deployment and DOE has a major responsibility to be part of the solution.

Required Areas for Reform

Restoring the LWR requires that we have reforms in three areas -- design, construction and licensing; the development activities of Westinghouse have their foundation in these areas. In our view, the DOE reactor development program must emphasize these elements and support the activities of the industry in advancing these reforms. The focus must be on advancing the

technology in these areas as a logical extrapolation of the current broad base of LWR design, licensing, construction and operating experience.

The Westinghouse program for development of the next generation of LWR designs -- the Advanced Pressurized Water Reactor (APWR) is a major cooperative effort with Mitsubishi Heavy Industries of Japan and a consortium of Japanese utilities. We and our Japanese partners are committed to completing this advanced design and building it in Japan in the not-too-distant future. Our incentive for developing this design is the need to remain competitive in international markets. The DOE program should build on these and similar efforts by our competitors in a way that supports and complements them for domestic applications and should have the following focus:

1. Simplification and incorporation of advanced features for improved constructability, reliability, operability, maintainability and reduced plant cost.

2. Development of advanced technologies for application to future plant designs, for example, utilization of artificial intelligence applications in advanced control room design and operations.

The direct focus of these development efforts within the existing LWR frame of reference will expedite their early application to future plants.

With regard to the licensing and regulatory process, "one-step licensing" could bring about significant improvements. Westinghouse has also developed an approach based on a partnership among the utility, regulators, suppliers, and financiers. Its implementation requires that at least 80 percent of the detailed engineering be complete prior to the issuance of a construction permit and the subsequent initiation of plant construction. We believe that the use of this pre-designed, pre-approved approach will avoid costly delays during construction as well as in obtaining an operating license.

Responsiveness of DOE LWR Program

Against this background, we have reviewed in detail the DOE LWR Program for FY '87. We find that it has the major elements needed -- the factors influencing licensing and regulatory and the work needed to simplify designs, improve designs and verify designs through the licensing process to be ready when orders develop from the utility industry. This latter program and the recently initiated DOE Advanced Light Water Reactor (ALWR) programs are also complementary to the EPRI initiatives on the LWR. The funding proposed is $29M - $11M on safety and licensing and $18M on the design and development - and is essential

considering the heavy investment by the utilities in nuclear power - the existing LWRs have a replacement value of $180B. It is also important to note that the funding proposed is modest -- 12% of the civilian reactor development program and 3.5% of the energy development programs (advanced reactors, fusion, fossil and alternative energy programs). Based on these considerations, there is strong justification for the $29M LWR program and we strongly support it.

Synergism of the Multimegawatt Terrestrial Power Plant and the ALWR Program

Westinghouse has developed a light water reactor concept for the Multimegawatt Terrestrial Power Plant (MTP) to provide secure, reliable, safe and economical power for military installations. This LWR design provides an opportunity for revitalization of the domestic nuclear industry. The walk-away safe concepts used in the MTP are being extrapolated to larger commercial scale nuclear power plant designs. The MTP emphasis on pre-packaged construction, which provides the cost, schedule and quality benefits of factory fabrication in lieu of field work, is also being stressed in the DOE ALWR program. System simplifications, a compact arrangement, and the human engineered advanced control room in the Westinghouse MTP concept are also synergistic to the ALWR program. Building the MTP on schedule and within budget will help restore confidence in the domestic nuclear industry and the MTP could serve as a showcase for the ALWR technologies.

Need for the Breeder

As I stated previously, the LWR option must be revitalized before there will be a need for advanced reactors of any type. I believe this revitalization will be achieved and domestic nuclear plants will be ordered beginning in the 1990s. Turning now to the breeder, it is government's responsibility to conduct R&D to ensure our country's energy security. The United States government, working in conjunction with the electrical utilities and with foreign governments, should be pursuing a plan that will have breeders available, when needed. Because this plan must also be realistic with regard to funding expenditures, the United States must focus its advanced reactor program by making decisions now.

Advanced Reactor Development Should Focus on the Liquid Metal Reactor

We believe that the advanced reactor program should focus on LMRs because LMRs will provide the technological bridge to the breeder. The world choice for nuclear power generation in the long term is clearly the Liquid Metal Fast Breeder Reactor. There are currently fourteen LMFBRs in operation, under construction or in design around the world and nearly 3000 MW of electricity are being produced by operating LMFBRs.

The most successful program is in France where the Phenix reactor has been producing electricity since 1972. On January 19, 1986, the 1200 MWe Superphenix reactor began providing power to the European grid. It is expected to be operating at full power by mid-1986. This is a major achievement obtained through the collaboration of the various European governments, utilities, and manufacturers in a focused program.

The United States program has also been successful - EBR II has been in operation since 1964 and FFTF has been operating since 1980. In 1985 FFTF achieved a capacity factor of 71% - truly remarkable for a test reactor that is carrying out a complex experimental mission.

Operating experience gained at FFTF is available to apply to the next generation liquid metal reactors. Operating experience with liquid metal systems and core and plant components at FFTF has been excellent and has enabled us to reduce operating costs and staff. Liquid metal reactor operating experience has also demonstrated total personnel exposures one to two orders of magnitude less than those for commercial light water power reactors.

Technical Challenges and Opportunities

Feasibility for LMRs has been established and valuable operating experience is being obtained with the multiple reactors

deployed worldwide. The major technical challenge for breeder development is achieving a reduction in capital cost to reach economic parity with other generating sources. It is our opinion at Westinghouse that this difficult cost target can be met by the time breeders are required. Westinghouse is currently working under DOE contract, in cooperation with Mitsubishi Heavy Industries of Japan, and independently on corporate funds, to achieve these objectives. Among the innovations we are developing are the significant economies associated with inherent safety and the use of long life cores.

The inherent safety features of LMRs provide the basis for eliminating core melt accidents as a licensing issue. The reactor system operates at low pressure and the liquid metal sodium coolant operates well below its boiling point, so there is no chance for the sodium to flash to vapor even upon depressurization of the system. The reactor can be designed so that off-normal events are terminated passively by the laws of nature and the heat can be removed by natural circulation. Excluding core melting as a credible event can eliminate the need for certain dedicated engineered safeguard systems and other expensive design conservatisms that have been used in previous designs. This, in turn, leads to significantly simplified plant design, improved overall plant protection, and lower capital costs.

The fuels development in FFTF is showing the capability for very high fuel burnups. At the end of 1985, the lead oxide fuel

experiment in FFTF reached a burnup of 152,000 MWD/MT, a world record for a full size fuel assembly. This compares to the original design burnup of the FFTF fuel of 80,000 MWD/MT.

Long Life Cores Offer Major Advantages

These advances in inherent safety capability and in the burnup capability of oxide fuel permit new design approaches for LMRs. These reactors can be designed to operate for 10 years or more without refueling. They are more efficient users of our fuel resources and they can be started with uranium fuel. Plutonium is formed and burned in place. This concept is applicable to a wide range of reactor designs and sizes. The economic potential is remarkably good, even without reprocessing. A power cost reduction of about 20% is estimated from the use of this technology.

The application of this long life core technology to LMRs also has major programmatic implications:

- o First, cost effective LMRs can be deployed before the fuel cycle is closed. The assured supply of enriched uranium can be used to fuel these reactors. Since the plutonium is formed and burned in place rather than being separated, and the feed uranium can be less than 20% enriched, freedom from proliferation concerns is an important benefit.

- o Second, existing facilities that fabricate fuel for LWR plants can be used to produce the enriched uranium fuel for these LMR plants.

- o Third, when reprocessing capability eventually becomes available, these liquid metal reactors can be converted to efficient breeder reactors.

The potential for long life cores is great. This was recognized by the Energy Research Advisory Board Subpanel on Advanced Reactors, which rated further development of long life cores as one of the highest priority areas. Yet the DOE proposed liquid metal reactor development budget for FY '87 allocates less than 1% of the budget to this area. I think this is clearly an area that deserves more emphasis in the DOE program.

FFTF is Essential to Support These Technological Developments

The Fast Flux Test Facility will play a key role in the technological development required to permit early introduction of LMRs and for LMRS to achieve cost parity with other electrical energy sources. Two major areas of testing are the demonstration of very high fuel burnup capability required for long life cores and the demonstration of the effectiveness of inherent safety features.

The Core Demonstration Experiment is the first large scale demonstration of the extended burnup capability of LMR mixed oxide fuel and blanket assemblies fabricated with an advanced cladding material. The test consists of fifteen fuel assemblies and eight blanket assemblies. The experiment is designed to operate for three years, with potential for continued operation well into the fourth year. Irradiation will start in mid-1986 and continue through mid-1990. Successful demonstration of burnup capabilities of 170,000 to 220,000 MWD/MT represents a factor of two increase in burnup capability, or a factor of two reduction in annual fuel requirements. Even higher burnup capability can be projected and demonstration of this projected capability should be pursued. Demonstration of this high burnup capability in FFTF will not only reduce LMR operating costs but also make feasible a once-through fuel cycle for early LMRs.

The inherent safety testing in FFTF will demonstrate that passive design features, relying just on the laws of nature, are effective in terminating off-normal conditions. Prooftesting these systems in an instrumented LMR environment under controlled conditions is an important step in the development of inherently safe designs. Future use of these design features in commercial LMRs could significantly enhance owner-investor and public confidence.

Why Should We Focus our Advanced Reactor Development on a Liquid Metal Reactor Using the Technology and Approaches that I Described?

The most important reasons are:

1. It will result in a safe simple reactor that has potential to compete economically with other electrical energy sources.

2. The advantage of the long life core can be applied to any of the innovative LMR plant designs.

3. It can use enriched uranium dioxide fuel - so no new fabrication plants are required.

4. It makes and uses Pu as it operates - so reprocessing is not required to obtain Pu. Since the Pu is not separated, it is free from proliferation concerns.

5. Much less waste results - because many fewer assemblies are discharged with a long life core.

6. Since the plant technology does not change, a very straightforward transition to breeding can be made when the need arrives.

Effective International Collaboration is Needed

As previously stated the need for the breeder is delayed, but the need will eventually occur. At the same time, funds available for advanced reactor development are limited so we must maximize the return on each dollar expended. An obvious path when funds are short is to focus the U.S. program such that it complements an international program - thus leveraging each dollar invested. Many areas of development and design exist in which collaboration is appropriate. This would also clearly provide a focused program with visible progress on a worldwide basis, and it would prepare us for the time when the need for the breeder arrives.

To achieve effective international collaboration, it is necessary to obtain a consensus on approach and to add international value to the U.S. advanced reactor development program. We should establish a national industrial design team under utility leadership and we should charter this team to develop a consensus design utilizing the innovative features from the current advanced reactor design studies. The design should be responsive to the requirements of the U.S. electric utilities and, wherever possible, it should also be consistent with the requirements of the programs overseas. This approach should provide us with a suitable vehicle for negotiating a collaborative program with our potential partners in Europe or Japan.

Summary of Recommendations

Let me summarize my overall recommendations.

1. Restore the LWR option through reforms in design, construction and licensing.

2. Design and construct the Multimegawatt Terrestrial Power Plant as a showcase for the Advanced Light Water Reactor Technologies, while meeting our power needs for military installations.

3. Focus our advanced reactor development on a cost competitive liquid metal reactor, as a bridge to the breeder. One effective means of implementing this would be through a national industrial design team.

4. Continue development of inherently safe cores and demonstrate those features in FFTF.

5. Develop the full potential of long life core technology, with supporting tests of high burnup fuel in FFTF.

6. Implement effective international collaboration in the development and design of liquid metal reactors to obtain leverage on the available funding.

Thank you for this opportunity to share my thoughts on this very important subject.

Senator DOMENICI. Thank you very much.

Dr. Armijo, I did not make your statement a part of the record. It will be, without objection, made a part of the record, yours and Mr. Arnold.

Dr. ARMIJO. Thank you.

Senator DOMENICI. I would like to also, at the conclusion of the testimony in the record, insert the excellent summary by Jerry Bishop of the Wall Street Journal. What date was this? Dated May 2, where the research breeder reactor number two that you have described was described by Mr. Bishop for the readers of the Wall Street Journal.

We will make that part of the record. He did a pretty good job of making it understandable to even people like me.

[The article follows:]

[From the Wall Street Journal, May 2, 1986]

ENGINEERS TAKE DIFFERENT PATH IN SEARCH FOR A SAFER REACTOR

(By Jerry E. Bishop)

On the morning of April 3, three weeks before the Chernobyl nuclear disaster in the Ukraine, a small, 20,000-kilowatt atomic reactor in Idaho, operating at full power, suddenly underwent one of the most dreaded occurrences in the production of nuclear power: The fluid that is supposed to cool the reactor stopped flowing.

Had this happened in a commercial power reactor, as it did at Three Mile Island in 1979 and possibly at Chernobyl last Saturday, another nuclear disaster would have been in the making. The cooling fluid would have immediately boiled away and temperatures in the reactor would have soared in minutes. Reactor operators would have scrambled frantically to get control rods pushed into the reactor to stop the atomic chain reaction before a "meltdown" of the uranium fuel core occurred.

When the loss-of-coolant incident took place in the Idaho reactor, however, engineers sat quietly, waiting to see what would happen. The temperature of the coolant did rise by 400 degrees Fahrenheit, but it didn't boil and continued to extract heat from the reactor. The atomic reaction stopped, and the coolant temperature dropped within five minutes to its normal 900 degrees.

The incident was the latest test by Argonne National Laboratory engineers of an advanced atomic power reactor that researchers claim is inherently safe. Known as experimental breeder reactor No. 2, or EBR-II, it is markedly different from the reactors that currently power the world's commercial nuclear electric-generating stations. The cooling fluid, which circulates through the reactor core, extracts heat from the reactor and transfers it outside where the heat is used to produce steam, is liquid sodium instead of water. And the uranium fuel is a metallic alloy instead of uranium oxide. These basic changes produce an atomic reactor that, according to the laws of thermodynamics and physics, can't go out of control.

Most commercial power plants use water to cool their reactors. Water boils at 212 degrees. To prevent the water from boiling away and allowing the reactor to overheat and melt, the cooling water has to be kept under pressures more than 100 times atmospheric pressure. Sodium, however, has a boiling point of 1,650 degrees and can keep absorbing the reactor's heat, cooling it, until it reaches that temperature. For this reason, the sodium doesn't have to be kept under pressure, one inherent safety advantage of the EBR-II.

Another safety feature is metallic uranium fuel. The metallic fuel is a far better conductor of heat than the oxide fuel used in commercial reactors. When the metallic fuel begins to overheat, the heat is quickly and efficiently conducted to the sodium coolant instead of building up inside the fuel as it does with the oxide fuel. As the heat spreads out evenly through the fuel, the sodium and the control rods, everything begins to expand. The expansion spreads the uranium atoms apart, slowing down the atomic chain reaction without any human or mechanical intervention. As the reaction slows, the temperature drops back to normal operating levels.

The EBR-II actually was built in 1964 to test out the concept of immersing a reactor in thousands of gallons of liquid sodium. But, says Charles Till, the associate laboratory director in charge of the Argonne program at the Department of Energy's Idaho experimental reactor facility, "Only in the last year or so did it become apparent that the reactor was inherently safe." After extensive experiments and

computer simulations, the engineers decided, perhaps for the first time in history, to subject an atomic reactor to the three most dreaded "postulated hypothetical accidents" that could happen to a nuclear reactor.

In the test on April 3, the circulation of the primary sodium coolant through the reactor was stopped. As predicted, the temperature of the sodium rose, and in minutes the power from the reactor dropped to almost zero as the chain reaction stopped, Mr. Till reports. That afternoon, in a second test, the flow of the secondary cooling system, which removes heat from the main system and transfers it outside the reactor, was suddenly shut down. Again, after a brief temperature rise, the atomic chain reaction came to a standstill and temperatures dropped to normal.

The engineers plan soon to put the EBR-II through the third-worst hypothetical accident, "an uncontrolled acceleration of reactivity," as it's called. If, in a conventional reactor, a vital control rod is accidentally pulled out of the reactor, the atomic chain reaction could get out of control, sending out lethal blasts of radiation and resulting in a core meltdown. The Argonne engineers are certain that when they jerk a control rod out of the EBR-II, the same phenomenon that prevented the other accidents will shut the reactor down.

Argonne, which is operated for the DOE by the University of Chicago, is now developing a prototype commercial power reactor, called the integral fast reactor (IFR), based on the EBR-II concept. If techniques for reprocessing the metallic fuel are worked out, researchers believe such inherently safe reactors could be operating in 15 years.

Dr. TILL. Thank you, Mr. Chairman.

Senator DOMENICI. I have a number of questions, but I am afraid we are not going to get to the next panel if I ask them. So I will ask the staff to submit them to you. If you will answer them at your next earliest convenience, perhaps in the next 8 or 10 days, they will be made a part of the record.

I was going to ask you, Dr. Armijo, do you have any relatives in New Mexico?

Dr. ARMIJO. Yes, many. My family has been in New Mexico since the late 1600's, and so we have lots of relatives in New Mexico.

Senator DOMENICI. And I know a lot of Armijo's and I wondered. In fact, I know some named Joe. They are not doctors, however, either medical or—where did you get your education?

Dr. ARMIJO. I attended Texas Western College in El Paso, TX. I am a Texan, and I know that is not very popular with New Mexicans, but my parents are both from New Mexico.

Senator DOMENICI. Are they still in New Mexico?

Dr. ARMIJO. No, sir. They are in Texas now.

Senator DOMENICI. How long ago did they move there? [Laughter.]

I mean, why do we always have to have such brain drains?

Dr. ARMIJO. They are right on the border, Senator. They are right on the border between New Mexico and Texas. [Laughter.]

Senator DOMENICI. How close? [Laughter.]

We are delighted, in any event, that we claim a part of you.

I do have some general questions, though, for Westinghouse and GE. What have the employment level trends in your reactor program areas been over the last several years?

Dr. ARMIJO. We in our advanced reactor—I will limit my remarks to our advanced reactors, or would you want me to cover both the commercial systems as well as——

Senator DOMENICI. Just the advanced is fine.

Dr. ARMIJO. In the advanced, we have suffered lots of cuts as a result of the Clinch River termination, where approximately 46 percent of our technical staff was lost as a result of the Clinch

River program reductions and the reductions in the base technology programs in DOE's program.

The fiscal year 1987 budget, if it holds, the DOE submittal, would pretty much finish the job. We would have cuts from approximately 120 people to something in the order of 30 people if those numbers hold. So that is certainly an unattractive prospect for us.

Dr. ARNOLD. For Westinghouse, the advanced reactor part, I think our story is quite similar to General Electric's, although the mix of specific programs is a little different. In the light water reactor area, the total level of employment has more or less held its own, with a minor cut of about 9 percent in the last year.

But there is a tremendous shift in the mix. There is no longer any original design work. It is trending heavily to service and refueling of existing reactors.

Senator DOMENICI. Let me ask one last one for all of you. Is the Nuclear Regulatory Commission doing enough in its safety research program or its licensing activities towards advanced reactor licensing efforts, as you see it?

Dr. ARMIJO. Senator, there is a review of the advanced reactors by NRC, including the liquid metal reactors and the HTGR Program, that NRC and DOE have reached agreement on. Year by year that has to be looked at again depending on the relative budgets of the two organizations.

But there is NRC review of these ideas that we discussed today.

Senator DOMENICI. Is it sufficient, as you view it?

Dr. ARMIJO. At this time I think it is sufficient. What we worry about is what happens next year with their budget as well.

Senator DOMENICI. Any other observations? About the same?

[Witnesses nod in the affirmative.]

Senator DOMENICI. All right. We will submit questions to you.

We will take the next panel, please: Mr. Fred Mynatt, Associate Director, Nuclear and Engineering Technologies, Oak Ridge; Dr. Richard Dean, senior vice president, GA Technologies, Inc., from San Diego, CA; Mr. Warren P. Chernock, vice president of advanced nuclear systems, Combustion Engineering, from Windsor, CT; and Mr. Richard F. Walker, chairman of Gas-Cooled Reactor Associates, of San Diego.

Let us proceed with Mr. Fred Mynatt first. Am I saying your name right or wrong?

STATEMENT OF FRED R. MYNATT, ASSOCIATE DIRECTOR, NUCLEAR AND ENGINEERING TECHNOLOGIES, OAK RIDGE NATIONAL LABORATORY

Mr. MYNATT. Yes, that is very close, Mr. Chairman.

I am Fred Mynatt, Associate Director of Oak Ridge National Laboratory for the areas of Nuclear and Engineering Technologies. I appreciate the opportunity to speak to you today. I have submitted my written testimony and I will summarize in the time available.

I want to speak on behalf of our reactor technology programs, including the consolidated fuel reprocessing program, the reactor technology programs for the Department of Energy, and some as-

pects of the reactor safety research program for the Nuclear Regulatory Commission.

All of these programs are severely impacted by the proposed 1987 budget. The reprocessing program is reduced from current year funding of $12.5 million to $1.5 million. The DOE reactor technology programs are reduced from $9 million to $6.5 million, with only $700,000 specifically identified for the high temperature gas-cooled reactor program.

The NRC reactor safety program is reduced from $14 million to $12 million. The net reduction in all of these programs which we call the civilian reactor programs is about $17 billion, which would mean the loss of approximately 290 staff members to the program.

The 1987 cuts are very deep and continue what has been the rapid elimination of the ORNL programs which prior to fiscal year 1984 were at over $65 million a year. The graph on page 2 of the material that I have submitted gives very dramatic and graphic evidence of these cuts, and unfortunately the extrapolation a year from now looks dysmal indeed.

The consolidated fuel reprocessing program has led reprocessing technology development in the United States for the past decade. It is a very effective and well focused program having obtained worldwide recognition in advanced technologies, including remote operation, remote maintenance, computer-controlled operation, proliferation resistant safeguards, waste reduction, and data from reprocessing of high burnup FFTF fuel.

For several years the program has focused on the development of advanced machines capable of remote operation, automation, and remote maintenance that have application to many areas beyond reprocessing. Well over $100 million over the years has been invested in developing the advanced machine technology.

Program termination will result in the loss of much of that technology because the loss of staff will prevent further development and technology transfer.

The Japanese plan to spend approximately $1 billion on reprocessing for their MONJU reactor, which will be completed in 1992. Considering their large program and the lead in areas of advanced remote technology which we presently have, the Japanese can save time and money by supporting continued development here in a collaborative program and by buying equipment here when the technology is transferred to U.S. industry.

While we in the United States are no longer committed to near-term commercialization of the breeder, we will also benefit greatly from a collaboration. We should continue, rather than lose the lead we have in advanced machine development, which will benefit U.S. industry, first in direct sales to Japan and later in applications other than reprocessing.

This collaboration over the next decade will provide a means for the United States to positively influence the emerging worldwide plutonium fuel cycle from a nonproliferation perspective.

By 1987, we need an absolute minimum of $5 million of DOE support to match a comparable amount provided to us by Japan. We will rapidly lose our technology lead and the funding reduction now in the 1987 budget will result in loss of the staff in the very near future without this action.

I recognize there are many pressures on the budget, but I can hardly imagine a better deal for the United States in terms of advanced machine development, international collaboration, and maintaining an important role in worldwide breeder development.

ORNL originated much of the gas-cooled reactor development in this country and now serves as the lead laboratory for the HTGR program. This includes overall program planning and evaluation, as well as the R&D work performed at ORNL.

We are also heavily involved in international cooperations between the United States and the Federal Republic of Germany and the United States and Japan in technology development, with emphasis on HTGR fuel performance. A recently signed agreement with Japan provides $2 million over 5 years of their funding to jointly fund fuel irradiation experiments.

Reducing the ORNL HTGR budget, as planned, to $700,000 in fiscal year 1987 will close out all HTGR technology development except part of this cooperative effort with Japan.

In the liquid metal reactor technology program, our world leadership in high temperature materials and structural design technology is being undermined by the recent budget cuts. For example, the improved 9 chromium, 1 molybdenum alloy developed by ORNL is a key to the economic advantage of advanced modular liquid metal reactors.

However, completion of critical materials properties and structural design data needed for nuclear code qualification of this material is being abandoned in the late stages of a multimillion dollar decade-long development program.

In another area, we have restructured our remaining DOE reactor technology program in the last year to increase the effort on advanced instrumentation and control. A thorough study of the needs with industry and universities revealed that now is the time to bring nuclear power into the modern age of advanced instrumentation and that such a program would be very effective. This program, under the name Advanced Control Test and Operation, or ACTO, will provide the development focus.

In the NRC research program, an area of particular concern to me is the elimination of NRC-supported research in instrumentation, controls, and human factors. We worked very hard to build excellent programs in these most difficult areas, only to see them eliminated.

Well over half of the risk in nuclear power operation is due to human factors and the man-machine interface. I am certain that when we learn the details of the tragedy at Chernobyl we will again learn that human error, compounded by faulty information, played a major role.

I wrote that statement last week and later in the week had some trepidation that perhaps there was a probability that I would be wrong. But the Soviets announced—it was in an AP press release Saturday—that human error is indeed a major factor in the accident that is underway in the Ukraine.

Also, the roles of chemistry and thermodynamics in the radioactive source term transport received appropriate attention after the Three Mile Island accident, but now are being reduced severely. On a positive note, work on pressure vessel integrity, reactor oper-

ations analysis, and plant aging research are making substantial progress, including such major issues as the resolution of pressurized thermal shock issue and implementation of a major computer data base and network for analysis of operating data.

I appreciate the opportunity to speak today. We have attempted to respond to budget constraints by providing low-cost collaborations with Japan in the areas of advanced machine development, by providing support as the lead laboratory to the HTGR option, by creating an advanced initiative in instrumentation and controls, and by a strong progressive reactor safety research program for NRC.

I feel it is important to proceed with these programs and to reverse the pattern of dismemberment of the civilian reactor programs that is evidenced in our budget.

Thank you.

[The prepared statement of Mr. Mynatt follows:]

TESTIMONY OF
FRED R. MYNATT, ASSOCIATE DIRECTOR
NUCLEAR AND ENGINEERING TECHNOLOGIES
OAK RIDGE NATIONAL LABORATORY

BEFORE THE SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT
OF THE
ENERGY AND NATURAL RESOURCES COMMITTEE
UNITED STATES SENATE

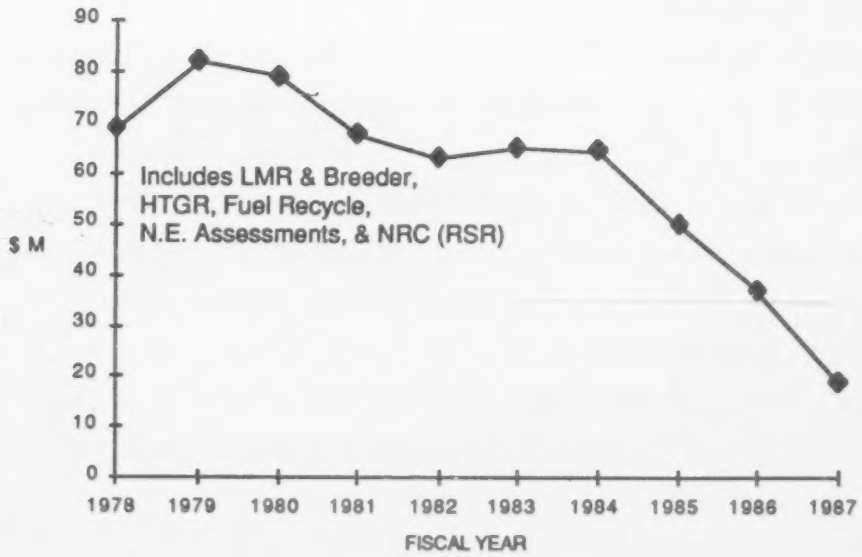
MAY 5, 1986

Impact of FY 1987 Budget on Advanced Reactor Technology Programs at Oak Ridge National Laboratory

Mr. Chairman and Members of the Subcommittee, I am pleased to speak to you today on behalf of the Reactor Technology Programs at Oak Ridge National Laboratory (ORNL) which is operated for the Department of Energy (DOE) by Martin Marietta Energy Systems, Inc. These programs include: The Consolidated Fuel Reprocessing Program and Reactor Technology Programs for the Department of Energy (DOE) and the Reactor Safety Research Programs for the Nuclear Regulatory Commission (NRC). All of these programs are severely impacted by the proposed 1987 budget. The Reprocessing Program is reduced from current year funding of $12.5 million to $1.5 million and the DOE Reactor Technology Programs are reduced from $9 million to $6.5 million with only $700 thousand specifically identified for the High Temperature Gas-Cooled Reactor (HTGR) program.

The NRC reactor safety program is reduced from $14.3 million in FY 1984 to $11.7 million in FY 1986. The net reduction in these Civilian Reactor Programs is about $17 million which would mean the loss of approximately 290 staff members. The FY 1987 cuts are very deep and continue what has been the rapid elimination of the ORNL programs which prior to FY 1984 were over $65 million a year. The following graph shows the decline in the ORNL budget from FY 1978 to the projected FY 1987 amount.

The Nuclear Technology Budget
at Oak Ridge National Laboratory
has declined dramatically in the last three years



CONSOLIDATED FUEL REPROCESSING PROGRAM (CFRP)

The Consolidated Fuel Reprocessing Program at ORNL has very effectively led reprocessing technology development in the United States for the past decade. It is a very effective and well-focused program having attained worldwide recognition in advanced reprocessing technologies including remote operation, remote maintenance, computer controlled operation, proliferation resistant safeguards, waste reduction, and data from reprocessing of high-burnup FFTF fuel. For several years, the program has focused on the development of advanced machines capable of remote operation, automation, and remote maintenance that have application to many areas beyond reprocessing. Well over $100 million has been invested in developing this advanced machine technology. Program termination will result in the loss of much of that technology because the loss of staff will prevent further development and technology transfer.

Over a year ago we recognized the high likelihood of continued severe budget reductions. We moved to complete our ongoing work quickly and to push technology transfer as hard as possible. We also began a significant effort to seek a broad collaboration with Japan in this field, consistent with DOE policy to stabilize programs at minimum costs through such means. Both we and Japan would benefit greatly from a collaborative effort that would continue our advanced technology development.

The Japanese plan to spend approximately $1 billion on reprocessing for their MONJU reactor which will be completed in 1992. Considering their large program and the lead in advanced remote technology which we presently have, the Japanese can save time and money by supporting continued development here and by buying equipment here when the technology is transferred to U.S. industry. While we in the U.S. are no longer committed to near term commercialization of the breeder reactor, we will benefit greatly from the collaboration. We should continue rather than lose the lead we have in advanced machine development which will benefit the U.S industry first in direct sales to Japan and later in applications other than reprocessing. We will also benefit by participation in the Japanese reprocessing program looking toward the future when we will return to breeder reactors. This collaboration over the next decade will provide a means for the U.S. to positively influence the emerging worldwide plutonium fuel cycle from a nonproliferation perspective.

For 1987, we need an absolute minimum of $5 million of DOE support to match a comparable amount to be provided to us by Japan. The time is now and action is required. We will rapidly lose our technology lead, and the funding reduction now in the 1987 budget will result in loss of staff in the very near future. I recognize the many pressures on the budget but I can hardly imagine a better deal for the U.S. in terms of advanced machine technology development, international collaboration, and maintaining an important role in worldwide breeder development.

HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR)

ORNL originated much of the gas-cooled reactor development in this country and now serves as the lead laboratory for the HTGR program. This includes overall technology program planning and evaluation as well as the R&D work performed at ORNL. The modular HTGR is a very attractive concept and when a demonstration plant is built it will be a stimulating option for the rebirth of nuclear power. In HTGR technology, ORNL is focusing efforts on fuel performance, fission product behavior, structural materials studies including graphite and metals, and shielding analysis. We are presently planning the technology development program for modular HTGRs in the fuel, fission products, graphite, and metals areas. ORNL is also heavily involved in cooperative programs between the U.S. and FRG and the U.S. and Japan in technology development, with emphasis on HTGR fuel performance. A recently signed agreement with Japan provides $2.05 million over five years to jointly fund fuel irradiation experiments.

Reducing the ORNL HTGR budget to $700 thousand in FY 1987 will close out all HTGR technology development except that associated with cooperative experiments with Japan and FRG. Even there, the amount is sufficient only to maintain an initial phase of cooperation in HTGR fuels testing, with significantly more funding required in future years. The overall effect of the FY 1987 budget is to close out most of HTGR technology development.

LIQUID METAL REACTOR (LMR)

In the Liquid Metal Reactor Technology Program, our world leadership in high temperature materials and structural design technology is being undermined by the recent budget cuts. For example, the improved 9Cr-1Mo alloy developed by ORNL is a key to the economic advantage of advanced, modular Liquid Metal Reactor concepts. However, completion of the critical materials properties and structural design data needed for nuclear code qualification of this material is being abandoned in the late stages of a multimillion-dollar, decade-long development program.

We have restructured our DOE reactor technology program in the last year to increase the effort on advanced instrumentation and controls. A thorough study of needs with industry and universities revealed that now is the time to bring nuclear power into the modern age of advanced instrumentation, and that such a program would be very effective and apply to all reactor types. The initiative includes advanced sensors that are self validating, fiber optics sensors and communications, distributed control using microprocessors, expert system software, automation with intelligent machines, and a simulation laboratory to develop and prove these technologies. Advanced reactors of any type must have advanced instrumentation, controls, and information processing. This program, under the name Advanced Control Test and Operation (ACTO), could provide the development focus. However, it will require a substantial investment to bring about these advanced control technologies. Current budget trends will not support the implementation of this important new initiative beyond a preliminary stage.

NRC RESEARCH PROGRAMS

Of particular concern to me is the elimination of NRC supported research in the areas of instrumentation, controls, and human factors. We worked very hard to build excellent programs in these most difficult areas only to see them eliminated. Over half of the risk in a nuclear power operation is due to human factors and the man-machine interface. I am certain that when we learn the details of the tragedy at Chernobyl we will again learn that human error, compounded by faulty information, played a major role. Also the role of chemistry and thermodynamics in the radioactive source term transport received appropriate attention after Three Mile Island but now is being reduced severely. On the positive note, work on pressure vessel integrity, reactor operation analysis, and plant aging research are making substantial progress including such major issues as resolution of the pressurized thermal shock issue and implementation of a major computer data base and network for analysis of operating data.

Mr. Chairman, I appreciate the opportunity to speak today. We at ORNL have attempted to respond to budget constraints by providing a very attractive low-cost collaboration with Japan to continue remote technology, advanced machine development and reprocessing expertise; by providing support as the lead laboratory for technology development for the modular HTGR option; by creating an aggressive initiative in advanced instrumentation and controls that will benefit all reactor concepts, and by a strong progressive reactor safety research program for NRC. I feel that it is important to proceed with these initiatives and reverse the pattern of dismemberment of the Civilian Reactor Program.

Senator DOMENICI. Thank you very much.
Dr. Richard Dean, senior vice president of GA Technologies.

STATEMENT OF DR. RICHARD A. DEAN, SENIOR VICE PRESIDENT, GA TECHNOLOGIES, INC.

Mr. DEAN. Mr. Chairman, my name is Richard Dean and I am senior vice president at GA. I am very pleased to appear before you to discuss the high temperature gas-cooled reactor, or HTFR, and other defense programs supported by DOE at GA. I ask that my prepared statement be made part of the record of the hearing.

Senator DOMENICI. Without objection, it will. I did not do that for yours, but it will be made a part of the record.

Mr. DEAN. The current gas-cooled reactor program is focused on the design, and development, of a modular HTGR which is passively safe, and economically competitive, for the generation of electricity and also process heat applications.

By "passively safe," I mean the safety of the public will be assured, without the reliance on any operator action and, furthermore, without requiring any active systems, such as pumps or motors or diesels or blowers, to operate. If the U.S. is to meet its energy needs that are required for it to remain a world leader, we must rely on coal and nuclear resources.

If nuclear power is to be an option, we must convince the public of its safety. We must convince the utilities, and the financial community, that investments in nuclear power plants are adequately protected.

The technical community accepts that our light water reactors are safe, but the public does not. The nuclear industry also has lost the confidence of the financial community, the rate regulators, and many Members of Congress.

I believe it would be very difficult and a time-consuming task to restore the confidence of the public, the financial community, and our elected officials, unless we provide an advanced reactor concept with more passive safety features.

Today, I believe it is appropriate, to insert a few words about graphite-moderated reactors, because Chernobyl was a graphite-moderated reactor. However, it was cooled by light water instead of inert helium. Furthermore, its fuel assemblies are quite similar to the fuel assemblies in our light water reactors.

However, they are arranged differently in pressure tubes, instead of a pressure vessel, and there are other differences. Because of Chernobyl, some people are getting the impression that all graphite reactors are unsafe. Nothing could be further from the truth. Graphite, which is stable at high temperatures, provides high heat storage capacity, and has long been considered a means of improving performance and safety. That is why graphite was selected as a moderator for the gas reactors.

How do we go about restoring confidence in the nuclear option? First, we think we should proceed with design development, and first of a kind engineering effort, on a modular HTGR demonstration plant. Then we should proceed with building such a plant on a Government site, and actually operating it under severe conditions,

to demonstrate its favorable safety features, and also to confirm the economic advantages of using a modular gas reactor.

Now, the cost of such a program would approach $800 million in today's dollars. But the private sector is willing to cost share such a project. If we were to make a united commitment, we could do this is 6 to 7 years. We strongly support the fiscal year 1987 funding recommendation of $27 million, for the modular HTGR, recently reported by the House Energy Research and Production Subcommittee.

However, that level of funding limits the progress we can make next year. The past 10 days at Chernobyl calls for an acceleration of this program.

We further recommend that $2 million be provided, to the NRC to assure the agency will perform the critical licensing review activities.

As a final note on the modular HTFR, essentially the same features that provide the passive safety, also provide investment protection of the plant in a passive manner. I may make a quick statement to follow up on Dr. Till's comments on EBR–II.

About 4 years ago, a loss of coolant test was run on the AVR 50 megawatt gas reactor in Germany. The plant started off at full power, they shut off the circulators and prevented circulation of the coolant. There was no control rod motion. The inherent negative reactivity shut the reactor down, and there was no damage to either the plant, or the fuel.

Now, with regard to the defense-related programs at GA, the space nuclear power program continues to concentrate on the development of thermionics technology. We have re-established manufacturing and testing expertise, including testing of full-sized thermionics cells in the GA TRIGA reactors.

Test results have confirmed design expectations that in-core thermionic systems can meet space power requirements, ranging from several kilowatts to multi-megawatts. We are developing a TRIGA power system to provide a compact, inherently safe, reliable power plant for the multi-megawatt terrestrial power plant project.

We are also involved in the manufacture, and supply, of nuclear fuel for the small nuclear power source demonstration project.

We fully support continuation of those programs, which will lead to nuclear systems capable of supporting our various defense objectives.

Finally, Mr. Chairman, I would like to express the appreciation of GA's management, and employees, for the past support your Committee has provided for the programs I have discussed here today. Your program guidance, and direction, have been helpful in achieving many milestones in the advancement of nuclear research.

Thank you for this opportunity to testify.

[The prepared statement of Dr. Dean follows:]

Statement Submitted for the Record

Senate Energy and Natural Resources Committee

UNITED STATES SENATE

FY '87 Department of Energy Budget & Policy

High Temperature Gas-Cooled Reactor Program

Thermionic Fuel Element Verification Program

Small Nuclear Power Source Project

Multi-Megawatt Terrestrial Power Plant

Dr. Richard A. Dean

Senior Vice President

GA Technologies Inc.

May 5, 1986

Mr. Chairman and Members of the Subcommittee:

I am Richard A. Dean, Senior Vice President at GA Technologies, Inc. I am pleased to have this opportunity to appear before your Committee and address the Department of Energy's FY'87 Budget Request for the Modular High Temperature Gas Reactor and areas of the DOE Defense Programs in which GA Technologies plays a role. I will also discuss our recommendations for the Nuclear Regulatory Commission's advanced reactor process and funding related to the MHTGR.

Briefly I would like to report on GA's pending change in ownership. This is especially important relative to our HTGR programs because GA has been and remains the industrial champion and vendor of gas reactor technology in the U.S. and is recognized as the primary repository of HTGR technology worldwide. Negotiations are nearing an end which we fully expect to lead to the sale of GA by Chevron to the Blue family of Denver, Colorado. The Blues are currently involved in the energy field via their ownership of gas utilities and oil and gas production activities. The Blues have indicated that the HTGR and our Doublet fusion programs as well as our recent entry into various defense areas were significant in their decision to purchase GA. They remain convinced that nuclear power will be an essential ingredient of the energy supply both in the U.S. and worldwide, and in particular, they view the modular HTGR as playing a major role in meeting this need.

Recently in testimony before the House Appropriations Committee, the Department of Energy indicated there was a lack of commercial interest in and commercial application for the MHTGR. I am sure the Committee finds this curious in light of the recent joint statement submitted to the Committee by Gas Cooled Reactor Associates, the utility organization formed more than 8 years ago representing 35% of the total electric generating capacity in the U.S. which has contributed financial support to lead to commercialization of gas reactor technology and from whose Chairman you will receive testimony later this afternoon. The joint statement indicating commercial support for the modular HTGR was signed not only by major U.S. utility executives but industrial participants such as GA, Stone & Webster, EG&G, Inc., Combustion Engineering and Bechtel Power Corporation.

In addition, GCRA recently surveyed the U.S. utilities as to their plans for future plant generating needs and found a large number of utilities which indicated they were planning for small incremental growth in their power generating equipment. Additions of 700 MW(e) or less as voiced by the large majority of the utilities fits squarely with the program direction of the modular HTGR in the 350 MW(t) range featuring passive safety, design and operational simplicity and the potential to achieve power costs competitive with modern coal-fired units and conventional light water reactors.

Needless to say, with this modular HTGR program gaining such momentum, we are concerned with the proposed shift in the nuclear energy strategy by the Department of Energy as stated in their Congressional budget request. This strategy, which redirects the efforts of advanced reactors, could make it most difficult for the nation to ever benefit from the potential of a system like the modular HTGR.

Therefore, we strongly support the FY'87 funding recommendation of $28M for the MHTGR recently reported by the House Energy Research and Production Subcommittee in the DOE budget recommendations both to the House Budget Committee and the full House Science Committee. This level of funding will allow the program to maintain critical momentum leading to the validation and demonstration of a focused, goal-oriented MHTGR program recognizing that private sector cost and risk-sharing arrangements will be a critical feature of the plan.

A key accomplishment over the last year was the development of a licensing plan which was submitted to and accepted by the NRC. This is aimed at supporting the submittal of a full preliminary safety information document during this current fiscal year. We therefore recommend that $2M be provided the NRC with appropriate report language to assure the Agency will perform the critical MHTGR licensing review activities.

The Space Nuclear Power Program at GA continues to concentrate on the development of thermionics technology in cooperation with Thermo Electron Corporation and Rasor Associates. The impressive progress in the last three years has reestablished manufacturing and testing expertise and includes testing of full-sized thermionic cells in the GA TRIGA reactors. Test results have confirmed design expectations that in-core thermionics systems can meet space power requirements from a few kilowatts to multimegawatts. Emphasis is being placed on the Thermionic Fuel Element (TFE) Verification Program which will demonstrate the technology readiness in the 500 kilowatt to 5 megawatt range. This three-year program, to begin in FY'86, will include design of a thermionic space reactor with an output of 2 MW(e) as well as testing of TFE converters in fast-neutron reactors at the Idaho and Hanford DOE facilities. The program will be supported by funds from the DOE Multimegawatt Program in FY'87. The objective of this work is to remove development uncertainties in the thermionic concept and to expedite the development of advanced converters that will provide dramatic improvements in electrode power density and efficiency.

GA is developing several thermionic reactor designs that offer great potential for application in the Multimegawatt Power Systems Program. These designs include the conventional thermionic converter approaches coupled with energy storage systems to

achieve 100 to 200 MW(e) and an innovative burst power concept that can produce 100 MW(e) in a closed cycle thermionic system. We at GA firmly believe that nuclear thermionic technology has the potential for application in a broad power spectrum that can enable space missions that require compact, lightweight and survivable power systems.

GA is developing the TRIGA Power System (TPS) to provide a compact, inherently safe, and reliable power plant for the Multimegawatt Terrestrial Powerplant (MTP) Project. The TPS combines two well-established and ideally-suited technologies: the TRIGA research reactor and the organic Rankine cycle power conversion system. We were joined by Chicago Bridge & Iron, Gilbert-Commonwealth, and Mechanical Technologies Inc. for the conceptual design study completed last year. The study showed that the concept, like the TRIGA research reactor, can provide a fully automated plant that can be operated by a small technician-level staff. Both fuel logistics and site requirements are minimized resulting in power generation costs competitive with similar sized fossil-fired plants. We fully support continuation of this program which will lead to the demonstration of a nuclear system which will satisfy the requirement for secure and reliable power for ground-based SDI systems and other mission-critical military installations.

GA is also involved in the manufacture and supply of nuclear fuel for the Small Nuclear Power Source Demonstration Project and we would encourage the Committee to continue its support for this project. We believe the application of Small Nuclear Power Sources is quite broad and will extend beyond potential use with the North Warning System.

Finally, Mr. Chairman, I would like to express the appreciation of GA's management and employees for past support your Committee has provided for the programs I have discussed here today. Your program guidance and direction have been helpful in achieving many milestones in the advancement of nuclear research.

Thank you for the opportunity to testify. I would be pleased to answer any questions you may have.

Senator DOMENICI. Thank you very much, Mr. Dean.

Warren P. Chernock, we are delighted to have you here and we will make your testimony a part of the record in its entirety.

STATEMENT OF WARREN P. CHERNOCK, VICE PRESIDENT, ADVANCED NUCLEAR SYSTEMS, NUCLEAR POWER SYSTEMS, COMBUSTION ENGINEERING, INC.

Mr. CHERNOCK. Mr. Chairman, I am pleased to have this opportunity to comment on some aspects of the DOE fiscal year 1987 budget request for fission research and development programs.

I also request that my written statement be made part of the record.

Senator DOMENICI. It will be, without objection.

Mr. CHERNOCK. Mr. Chairman, I am going to digress from what I had planned to say for just 1 minute or 2, if you will indulge me. You are, if you pardon the expression, a little bit unwilling to take credit for something that you were instrumental in in my testimony or as a result of my testimony in front of your Committee in 1982.

When I look at the results of the first panel discussion, if you will recall, you and I had a discussion in 1982 in which I indicated to you that I did not think that there was any R&D program that was being pursued by the Government that had a greater benefit/cost analysis than the program that was being pursued by DOE in the area of extended or high burnup fuel.

I emphasized at that time that it would have important aspects on the waste program. I think that the results of that program have borne fruit and I think that you will find that it has had an important impact of the waste program. With high burnup fuel, you have fewer fuel assemblies to be concerned about in the waste program, and I believe that if we could refer back to that testimony and possibly think about including it as part of this record, I think you will find it will have impact on your deliberations with respect to panel number one.

Senator DOMENICI. The staff will find that for us. While we almost always accept recommendations of distinguished people like you, we will reserve judgment and read it first, and then we will decide. Is that all right with you?

Mr. CHERNOCK. Yes, that is fine. I believe your distinguished help was extremely helpful in pursuing that program.

Senator DOMENICI. We will do that.

Mr. CHERNOCK. In the near term, the best opportunity to restore the nuclear option is to build upon proven light water reactor technology. Thus, we are pleased to note the cooperative effort between DOE and EPRI in the development of detailed requirements for future light water reactors and the certification of designs incorporating these new requirements.

This combined effort aims at ensuring that lessons learned during the operation of light water reactors are fed back into design requirements and that resultant design changes will involve NRC early in the design process to achieve design certification in an efficient, responsible, and expeditious fashion.

This cooperative effort between DOE, EPRI, NRC, the utilities, reactor vendors, and architect-engineers represents a unified and cooperative national program which will be vital in restoring the nuclear option by building on proven light water reactor technology.

Combustion engineering is totally supportive of this program and we recommend that the proposed funding level for this effort for fiscal year 1987 remain intact, even in light of our recommendation on increases in fiscal year 1987 funding for the modular HTGR.

However, we recommend that the direction of the DOE effort in support of the EPRI light water reactor program be more heavily focused on additional support of the EPRI requirements and DOE design verification efforts, even at the expense of application of Government funds for additional design and development of so-called advanced light water reactors being designed in conjunction with foreign partners overseas.

I would like to again commend the foresight which your Committee has recognized concerning the inherent safety characteristics of the modular HTGR and the importance of this program to this Nation. HTGR program participants have pooled their efforts to arrive at a consensus design to become the focal point of a unified national HTGR program. This design is a 350 megawatt thermal side by side steel vessel reactor with prismatic fuel and an annular core. It is this design which now forms the basis of a PSID being pursued by DOE.

The selection process emphasized the utility user and regulatory requirements against which design concepts were evaluated. These requirements now form the basis for continued modular HTGR design efforts. In addition, a licensing plan for the modular HTGR was accepted by the NRC and forms the basis for the PSID submittal to NRC in fiscal year 1986.

There is a need for the formation of a strong industrial team with clear responsibility and authority to design and construct the demonstration plant. The combustion engineering record for engineering excellence and project and systems management of nuclear systems, combined with the strong HTGR technology base provided by GA technologies, provided the basis for formation of such a team.

Combustion Engineering and GA Technologies have exercised a memorandum of understanding on the joint venture HTGR company. However, as a result of the sale of GAT by Chevron this memorandum of understanding requires assessment by the new owners.

We feel confident that this industrial team will emerge as the flagship for the HTGR program both with respect to design, development, and construction of the demonstration plant, as well as future commercialization of HTGR's. Although budget restraints are severe, this program deserves your attention for increased funding in fiscal year 1987 to maintain the momentum which was difficult to achieve and for which your Committee should be proud.

Mr. Chairman, let me reiterate Combustion Engineering's support of the modular HTGR program. We recommend that the budget for fiscal year 1987 for the modular HTGR be increased to the $32 million level recommended in the joint participants' statement which is attached to Mr. Walker's written testimony.

We also recommend that $2 million be provided to the NRC to provide a basis for adequate licensing review and the issuance of a licensability statement.

The modular HTGR and the liquid metal reactor have different roles within the DOE advanced reactor program, and we recommend that development of both concepts be continued. This recommendation to continue current development of both concepts is in agreement with the recommendations made in the April 1986 executive summary of the advanced reactor development subpanel of the Energy Research Advisory Board's Civilian Nuclear Power Panel.

We support the testimony of John McDonald of Rockwell International concerning the benefits and advantages of the SAFR modular LMFR concept which now can incorporate the advantages of metal fuel described by Dr. Till of Argonne National Laboratory in his testimony.

We recommend that the modular LMR funding level proposed by the House Subcommittee on Energy Research and Production, chaired by Representative Lloyd, be maintained.

Mr. Chairman, I thank you for the opportunity to provide comments to this committee.

[The prepared statement of Mr. Chernock follows:]

STATEMENT SUBMITTED TO

SENATE ENERGY AND COMMERCE

ENERGY RESEARCH AND DEVELOPMENT SUBCOMMITTEE

FY 1987 DEPARTMENT OF ENERGY NUCLEAR RESEARCH AND DEVELOPMENT PROGRAMS

Warren P. Chernock
Vice President, Advanced Nuclear Systems
Nuclear Power Systems
Combustion Engineering, Inc.
May 5, 1986

Mr. Chairman and members of the Subcommittee, my name is Warren P. Chernock. I am Vice President, Advanced Nuclear Systems, at Combustion Engineering, Inc. I am pleased to have this opportunity to comment on some aspects of the DOE FY 1987 Budget Request for Nuclear Fission Research and Development Programs.

SUMMARY

In the near term, the best opportunity to restore the nuclear option is to build upon proven Light Water Reactor Technology. The cooperative effort between DOE and the Electric Power Research Institute (EPRI) in the development of detailed requirements for future PWRs and verification of designs incorporating these new requirements is an important facet in restoring the nuclear option. We recommend that the DOE proposed funding level for this effort for FY 1987 remain intact, even in light of our recommended increases in FY 1987 funding for the Modular HTGR. However, we recommend that the direction of the DOE effort in support of the EPRI LWR program be more heavily focused on additional support of the EPRI requirements and DOE design verification efforts even at the expense of application of Government funds to enhance design and development of "so-called" advanced LWRs being designed in conjunction with foreign partners overseas.

The Modular High Temperature Gas Cooled Reactor has unique characteristics which are particularly useful in achieving the objectives of the advanced reactor program.

This is the only one of the advanced concepts which can withstand a total loss of coolant. Its high temperature capability makes it uniquely suited for applications in addition to electricity generation. Such applications include process heat, the transportation industry and other high energy consumption industrial sectors. The DOE MHTGR Program has gained significant forward momentum during the past year. A consensus design has been developed by DOE program participants. This design is a 350 MW thermal side-by-side steel vessel reactor with prismatic fuel and an annular core. It is this design which now forms the basis of a PSID being pursued by DOE. An objective to obtain an initial statement of licensability from the NRC will require adequate funding for both DOE and NRC in FY 1987. In particular, we recommend that the budget for FY 1987 for the MHTGR be increased to the $32M level recommended in the Joint Participants' Statement which is attached to Mr. Walker's written testimony. We recommend that $2M be provided to the NRC to provide a basis for adequate licensing review and the issuance of a licensability statement.

A utility contemplating the purchase of a nuclear plant with a projected lifetime of forty to sixty years will want assurance of an affordable fuel supply over that span of time. The Liquid Metal Reactor (LMR) has been chosen throughout the world as the best way to breed plutonium. The unique features of the DOE Modular LMR concept currently under

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development, for example the SAFR Design, involve a coolant which is not under pressure so that the primary coolant boundary is not highly stressed. The probability of leaks and loss of coolant accidents are minimized. Natural circulation is readily achievable in liquid sodium and the large coolant mass leads to desirable slow response to upsets. Thus, the Modular LMR is a strong candidate to meet the objectives of the advanced reactor program while providing a "bridge" to the breeder when this is needed to supply fissile fuel. We recommend that the funding level proposed by the House Subcommittee on Energy Research and Production, chaired by Ms. Lloyd, be retained to maintain momentum on this important program.

The MHTGR and the Modular LMR have different roles within the DOE Advanced Reactor Program, and we recommend that development of both concepts be continued at the funding levels proposed above. This recommendation to continue current development of both concepts is consistent with the recommendations made in the April 1986 Executive Summary of the Advanced Reactor Development Subpanel of the Energy Research Advisory Board's (ERAB) Civilian Nuclear Power Panel.

DOE/EPRI COOPERATIVE EFFORT ON LWRs

Combustion Engineering, Inc. agrees with the views expressed by DOE that, in the near term, the best opportunity to restore the nuclear option to the electric utility industry is to build upon proven Light Water Reactor (LWR) technology.

In more than twenty-five years of commercial operation, light water reactors have proven themselves to be safe, economic and environmentally acceptable. We are pleased to note the cooperative effort between DOE and EPRI (representing the utility industry) in the development of detailed requirements for future LWRs and verification of designs incorporating these new requirements. This effort is aimed at ensuring that lessons learned during the operation of LWRs are fed back into design requirements and that the resultant design changes will receive the involvement of the Nuclear Regulatory Commission early in the design process with the aim of achieving design verification in an efficient, responsible and expeditious fashion. This cooperative effort between DOE, EPRI, NRC, utilities, reactor vendors and architect engineers represents a unified and cooperative National Program which will be vital in restoring the nuclear option by building on proven LWR technology. Combustion Engineering is totally supportive of the DOE program. However, we believe that more DOE effort should be applied in support of the EPRI Requirements and the DOE Design Verification Programs even at the expense of application of funds to enhance design and development of "so-called" advanced LWRs being designed in conjunction with foreign partners overseas. I believe that U.S. utilities will resume the construction of new nuclear plants only if the designs meet the needs of these utilities and are not simply adopted from foreign developments. An article in Forbes magazine last year made a convincing argument

that what works overseas may not work in the U.S. because of our major institutional differences. What the utilities need are simplified, licenseable plant designs that are easier to construct and operate, yet, based upon proven technology. These are major objectives of the EPRI program. DOE's participation in this effort is essential for the program's success and will benefit the American public by restoring the nuclear option. We are pleased to endorse also the new DOE Advanced Reactor Severe Accident Program as an important input to the joint EPRI/DOE effort. The objective of this program is to assure that potential accidents involving core damage are adequately studied and the results factored into future plant designs.

NEED FOR ADVANCED REACTOR PROGRAMS

Looking farther ahead, we see an exciting opportunity to develop reactors which might better meet some of the then existing market niches, both foreign and domestic, in terms of size, utility cash flow, licensing stability and dependence on operator response. These reactors have the important additional value of establishing a greater product mix in the long term when, inevitably, low-cost resources of oil and uranium are depleted.

It is my opinion that protecting our national energy interests is paramount. We need to extend nuclear power applications to process heat, the transportation industry and other high energy consumption industrial sectors, and we must provide for an adequacy of nuclear fuel in the long term.

Our influence on international markets will only occur if the U.S. nuclear option is restored. Extensive foreign collaboration under terms of a weak U.S. advanced reactor posture could lead to eventual dominance of foreign suppliers within the U.S. We need to evaluate the advantages of foreign technology adoption in the short term versus the everlasting long term impact of U.S. market dependence on foreign suppliers. Do we wish to mortgage our future because of inadequate Federal support now for advanced concepts?

The mission of the Department of Energy is to ensure a stable and secure energy supply for the United States. Their contribution is especially important when considering long term trends which the private sector finds difficult to handle.

It is not popular to talk about shortages of uranium and oil at a time when the miners are strongly encouraging DOE to force the use of domestic ore and OPEC is engaged in a price war against non-OPEC producers, yet history has demonstrated that such matters will not impact long term trends. Policymakers must look far ahead if they are to take the essential steps now to avert the problems which can be foreseen with great certainty. It is simply not possible to just wait until oil or uranium prices have "gone through the roof" and then immediately build, say 100 GWe of HTGR capacity by Congressional fiat. The technology, the manufacturing capacity, the operating experience, the regulatory structure, and the public acceptance must be

painstakingly built up in an orderly manner and the time to begin is now.

The development of advanced reactors is not something that can be handled by private enterprise alone. The development costs are large (although not unprecedented) as are the risks. Development schedules are protracted. In addition, there are institutional problems far beyond the control of the private sector: the NRC, state utility regulators, vocal and effective anti-nuclear activists and an adversarial press. These obstacles, especially for new concepts, impose major incentive restrictions on the reactor suppliers.

It is thus incumbent upon DOE, with the mission of assuring the Nation's energy supply and security over the long term, to sponsor most of the necessary development costs through the demonstration stage, including the issuance of a standard design certificate from NRC. The effort will go for nought unless it can compete in terms of some combination of cost, size, construction time, or special characteristics with the alternatives available in the late 1990's.

Some demonstration plants are necessary if private sector commitments for later commercialization are to be made. Such private sector commitments would be expected to increase as risks are reduced through design, licensing, construction and operation. However, DOE must be willing to accept a major share of the financial risk of an advanced reactor demonstration plant. In addition, support by the utility industry is required. The principal purpose of

demonstration plants will be to confirm the performance, reliability, cost and construction schedule for advanced reactor concepts.

The criteria for demonstration plants should include answers to at least the following questions:

- Does the concept serve the long-range energy needs of the U.S.?
- Is the concept one that utilities will buy and vendors will offer? (This requires substantial utility and vendor interaction in design decisions concerning the demonstration plants even if the major costs are borne by DOE.)
- Are the claims of performance, cost and schedule realistic and substantiated?
- Is there a realistic plan to build, test and deploy?
- Is licensing stability a dream or a reality?

CHARACTERISTICS OF ADVANCED REACTORS

Because of the importance of achieving licensing stability and reducing the costs associated with meeting licensing requirements, there is a strong incentive to develop designs which rely on inherent physical properties for safety and protection of the plant. Such designs would have safety features which are simpler, less expensive and more obvious in their operation than the engineered safety systems and multiple redundant support systems which characterize current reactors. The need for rapid, accurate response by skilled operators would be minimized.

The ability to demonstrate the safe behavior of the system under a variety of extreme design basis conditions, such as loss of all power without any operator actions, would help to restore public confidence in the safety and acceptability of nuclear power.

Costs would be reduced by fabricating most of the safety-related equipment in the factory under quality controlled conditions allowing most of the field work to be done relatively quickly and inexpensively by conventional commercial methods.

MODULAR HTGR

The MHTGR has unique characteristics which are particularly useful in achieving the objectives of the advanced reactor program. The fuel is able to withstand high temperature (2900°F) during an accident without damage and without releasing radioactivity. Fission products are retained in the fuel under all conditions with almost none released to the coolant or the reactor building. Because of the large heat capacity in the core, many hours are available for remedial action in the event of an upset.

This is the only one of the advanced concepts which can withstand a total loss of coolant. All the decay heat can be dissipated by radiation and conduction to the reactor vessel and from there to the air-cooling system of the reactor enclosure. The coolant, helium, is a non-corrosive gas avoiding concerns for corrosion and the complications of possible phase changes which are associated with liquid coolants.

Another important attribute of the MHTGR is that its high temperature capability makes it uniquely suited for applications other than electricity generation. Since only one-third of the Nation's primary energy requirements are for the generation of electricity, there is a large market here currently served by oil and gas for the most part. Inevitably, these non-renewable resources will be depleted and prices will rise. At that time the availability of the MHTGR may be extremely important to the Nation's economy.

The DOE program has been reoriented toward the objectives described above via the selection of the prismatic fuel, annular core design. The THTR in West Germany is now operating. Continued successful operation of this 300 MWe power plant will give that country a significant advantage in any international competition for HTGR business and could lead to the direct supply of German HTGRs to the U.S.

With respect to the near-term development of the MHTGR, we believe a demonstration plant is necessary to focus the design and development effort, to confirm the performance, cost estimates and schedule, and to establish licensing rquirements by assisting in securing a Standard License from NRC.

It will be very difficult for the private sector to finance such a program without significant commitments from DOE.

For FY 1987 in particular, the objective has to be to obtain an initial statement of licensability from the

NRC. Both NRC and DOE need to be adequately funded for this purpose.

Once a demonstration plant has been built and operated successfully, we have no concern over the commercial applicability of the MHTGR. The Joint Statement of Support attests to the interest of potential customers for this concept.

MODULAR LMR

The Modular LMR builds on a broad technical base of world-wide experience dating back to the EBR-1, the first nuclear reactor to generate electricity for commercial application. The LMR has been chosen throughout the world as the best way to breed plutonium from non-fissile uranium, something that will eventually become very important to do.

A suitably designed LMR meets the U.S. objectives previously discussed. Unique features are that the coolant is not under pressure so that the primary coolant boundary (i.e., the reactor vessel) is not highly stressed. This minimizes the probability of leaks and loss of coolant accidents. In addition, natural circulation is readily achievable in liquid sodium and provides good self-cooling properties for the reactor. The large mass of coolant in the vessel provides large heat capacity, leading to desirable slow response to upsets. For these reasons, among others, the Modular LMR is a strong candidate to meet the near-term objectives of the advanced reactor program while serving as a "bridge" to the breeder when this is needed to supply fissile fuel. As with the HTGR, a demonstration plant will be needed to demonstrate the desirable features.

Mr. Chairman, I would like to thank you and other members of your Subcommittee for the opportunity to comment on these DOE programs.

Senator DOMENICI. Thank you very much.
Mr. Walker of Gas-Cooled Reactor Associates.

STATEMENT OF RICHARD F. WALKER, CHAIRMAN AND PRESIDENT, PUBLIC SERVICE COMPANY OF COLORADO AND CHAIRMAN, GAS-COOLED REACTOR ASSOCIATES

Mr. WALKER. Thank you, Mr. Chairman. It is my pleasure to testify on the DOE advanced reactor program. I am Richard F. Walker. I am chairman of the Gas Reactor Associates. I am also chairman and CEO of the Public Service Company of Colorado.

The Gas-Cooled Reactor Associates is an organization of a number of major utilities in the United States that for a number of years as utility users have supported the high temperature gas-cooled reactor concept. I might add parenthetically that we are the only active organized utility group supporting a specific reactor design at this moment.

I certainly too would acknowledge this subcommittee's support over the past years in helping us secure DOE funding to continue the high temperature gas-cooled reactor design and definition work.

A number of years ago, we worked very diligently on a larger HTGR, a reference design, if you might call it that. For the last several years, the emphasis has switched to a modular HTGR that Mr. Chernock and Dr. Dean have testified to.

On the electric side, it turns out to be 140 megawatts electric, and some of its characteristics, besides its smaller size, lower power density, self-cooling, it looks to me like it is a real candidate for certification of a true standard modular unit that could be built and installed with some degree of confidence.

The size is to me very important in that, as the utility executive, much to our chagrin, the electric load requirements in this country have not grown as they did in the seventies, and most of us are not experiencing very large amounts of load growth.

It is necessary then for us to be able to program into our system smaller amounts of capacity. A modular system such as this, where you could group two or four 140 megawatt electric together, you get 560, if you only needed 280 you could get 280, we see this as a real advantage in financing and construction, particularly if there was true certification so that you would not have to go through with every module a great long licensing process.

Mr. Chernock indicated that there was a statement attached to my testimony, which is a joint statement of 20 major companies, including utilities, vendors, architect-engineers, and I certainly endorse that and support that statement.

I did not indicate earlier, Mr. Chairman, I would like my full statement to be included as part of the record.

Senator DOMENICI. It will be.

Mr. WALKER. I am obviously paraphrasing from the statement.

We need the support to continue. We are getting—we have had the project reasonably well defined from the technical aspect and what size and configuration arrangements. Now we need to identify cost estimates, schedules, and institutional arrangements to get this done.

Mr. Chernock referred to a vendor. I call it a project supply company. We think it is very important that this be put together with more than one vendor so that we do have a true supply company that could provide this for us. On the utility side, we need a utility project partnership, which we are working on, to get a number of utilities together that could go into this on a joint basis.

Obviously, in today's economy we cannot support this by ourselves, and it is going to require the Department of Energy to be a partner in this. We recognize that it is also necessary that we do our share, and certainly an equal sharing of costs in the long run is certainly appropriate to get this done.

For our continued work, we have picked the Idaho National Engineering Lab site to do our reference design studies. That would be an excellent place to build the 140 megawatt electric module, to take it through a full demonstration phase, to prove to everyone its ability to self-cool, its ability to be operated with a minimum of safety systems. And we are looking forward to continuing that study.

I too support the recommendation of $32 million for the Department of Energy in the advanced reactor field; also, $2 million for work at the Nuclear Regulatory Commission, because it is very important and a keystone to this program is being able to have licensability or having real assurance that we could license and certify this thing before any of us proceed with this type of project, whether it be the supply company, the utilities, or the Federal Government.

That is the way we see it. We think it is worth continuing. We think an advanced reactor concept is vitally needed in this country for a number of reasons: our prestige, our need for power, and so we are enthusiastic. We hope to continue this work in spite of some of the things that have gone on lately.

So I wholeheartedly endorse the DOE continuing. They just need a little more money than they have programmed to really carry on the job that I would like to see done.

Thanks again to your subcommittee for its support in the past, and we certainly have appreciated it.

[The prepared statement of Mr. Walker follows:]

STATEMENT SUBMITTED FOR THE RECORD
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

FY 1987 DOE AUTHORIZATION FOR
HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

RICHARD F. WALKER
CHAIRMAN & PRESIDENT OF PUBLIC SERVICE COMPANY OF COLORADO
AND
CHAIRMAN OF GAS-COOLED REACTOR ASSOCIATES

Mr. Chairman and Members of the Subcommittee, my name is Richard F. Walker, and I am Chairman and President of Public Service Company of Colorado and Chairman of Gas-Cooled Reactor Associates (GCRA) which is a utility/user organization that supports the development and commercialization of the High Temperature Gas-Cooled Reactor (HTGR).

Historically, the basis for utility/user support for the HTGR is its high temperature capability which offers increased efficiency for electricity generation, and the unique potential to access cogeneration and high temperature process heat markets. From both the utility/user and National perspectives, these characteristics alone provide sufficient basis for priority development. However, of increasing importance are the HTGR's unique features which are directly responsive to the current institutional issues that plague the nuclear industry. The most notable of these features are the inherent safety and low environmental impact characteristics that translate to minimal reliance on engineered safety systems, substantial time (measured in hours) for operator response to postulated reactor upset conditions, added margins for plant investment protection and siting flexibility, and low radiation exposure of plant personnel. As a result, the HTGR technology offers an advanced, second generation of nuclear power that provides the basis for a fundamentally different approach to licensing and a fresh approach to public/investor acceptance.

GCRA's goal is to ensure that the HTGR is established as an attractive commercial alternative for a broad range of applications in a timely manner. The approach to achieving this goal has been to establish a National Demonstration Project after which commercial plants can be deployed. In achieving this goal, maximum use will be made of the past 35 years of worldwide gas-cooled reactor technology, demonstration and application. During the past several years, the focus of the collective efforts within the HTGR Program has been to develop an HTGR design that is responsive to the utility/user's requirements, eases the current institutional difficulties associated with nuclear power and optimally capitalizes on the HTGR's unique characteristics.

As you know, the result of this effort has been the establishment of the Modular HTGR (MHTGR) as the reference concept for near-term development and deployment emphasis. The strong consensus of support within the Program participants and the broad utility support for the MHTGR is reflected in the recent Joint Participants' Statement to this Committee and the other Congressional Committees which have oversight responsibility for the HTGR Programs at the DOE and the NRC. We heartily endorse the Joint Statement and are proud to have coordinated its preparation and submittal. A copy of the Joint Statement is attached for the Congressional Record.

As a supplement to the Joint Statement, I would like to expand on GCRA's Project development activities. From its inception, GCRA has sought to establish a National HTGR Demonstration Project that would be based on an equitable cost/risk sharing between the utility/user industry, the vendor/AE industry, and the Government. While the overall environment for any civilian nuclear project has become increasingly difficult and the proposed FY 1987 budget proposals from DOE would appear to discourage our Project interests in particular, we remain committed to pursue an MHTGR Project initiative. This position is based on our conviction that the merits of the MHTGR are worthy of a National Demonstration Project.

Fundamental to the MHTGR concept is the ability to build a one-module Demonstration Project, at relatively minimal cost, as the demonstration basis for multi-module commercial plants. Through an initiative begun by TVA and expanded by GCRA, the optimum approach for such a one-module Demonstration Project is being expanded through an ongoing MHTGR Project Definition Study. Phase I of this Study was begun last August and completed in February and was supported by all the private-sector Program participants. Through this Study, the following Project objectives have been established:

1. Demonstrate HTGR-Unique Licensing Process and Support the Design Certification for the Standard Nuclear Island - Through the reference plant design effort, a disciplined "requirements" based approach to licensing is being developed that should fully capitalize on the HTGR's unique safety characteristics. This process will be put to practice and demonstrated through such a Project. In addition, if Project licensing issues, standard nuclear island design certification issues, or future licensing racheting issues are identified which are not amenable to ready resolution via analysis or separate effects testing, the Project could be used to prototypically test the reactor module and nuclear island response to key design basis events as a potentially efficient and convincing supplement to the overall licensing process.

2. Demonstrate Plant Performance Characteristics - Albeit a one-module plant, it will provide the performance demonstration of a full scale reactor module and its interaction within the nuclear island and the overall plant. In addition to the normal steady state power operations and anticipated transients demonstration, design basis events may be demonstrated to verify inherent safety and investment protection features of the plant. This will provide the confirmatory basis for acceptance of design features on a realistic basis as opposed to the more conservative basis that is often required when extrapolating from analyses and separate effects testing.

3. Demonstrate Operation and Maintenance (O&M) Activities - The Project will provide for a demonstration of normal O&M activities as well as identify and demonstrate any O&M activities which might be required in the unlikely event of major equipment failures. This will provide feedback to the commercial plant design plus provide a strong basis for commercial plant O&M cost estimates. In addition, a reliability improvement program will be established as an integral part of the Project. Long-term operation will provide more extensive reliability data and early indication of problems which may arise with extended operation. Other potential benefits which may be derived from the Project include operator training for subsequent commercial plans and long term component and material surveillance.

4. Establish Basis for Commercial Plant Cost and Schedule - The Project will provide the first-of-a-kind experience for adapting modular fabrication techniques and separation of the nuclear island and turbine island portion of the plant. The cost and schedule experience in the overall design, licensing, fabrication and construction effort will serve as invaluable demonstration experience for prospective vendors and customers. Further, the Project will foster the development of one or more vendor/supplier entities and related infrastructure for offering subsequent commercial plants.

5. Establish Utility/User/Investor Confidence to Buy Commercial Plants - Based on reasonable success with all the above objectives, the Project will be invaluable for establishing a base of confidence for future MHTGR commercial plant owners and their investors.

Through the Project Definition Study, an initial definition of the requirements and scope, an initial detailed estimate of the costs and schedule, and the overall benefits and specific limitations of the prospective MHTGR Demonstration Project have been established. Further, INEL has been established as the reference site for the Project because of the added flexibility for testing and demonstration afforded by the site's remoteness plus the availability of valued facilities and human resources to support the Project. Summary results are reported in the Joint Statement and further details are available upon request.

Based on the results of an initial phase of a Demonstration Project Definition Study, a draft outline of a Project Strategy Plan has evolved through a parallel GCRA initiative that addresses the proposed organizational/management roles, including the cost/risk sharing arrangements. To that end, efforts are underway to establish a Utility Project consortium that will own and operate the Demonstration Project and provide the major share of utility financial support for the Project. In addition, it is envisioned that a Project Supply Company will be established to consolidate the design, manufacturing and construction management resources for the Demonstration Project as well as provide cost/risk sharing support. If successful, the Project Strategy Plan will become an agreed-upon foundation for the utility/user industry, the vendor industry and the Government for establishing a Project based Program and committing their support for the Project.

Crucial to the furtherance of the MHTGR Project initiative is stable Government support. Accordingly, GCRA respectfully recommends that Congress provide $32 million, including one million for capital equipment, for continued MHTGR development within DOE's Advanced Reactor Program in FY 1987. Further, the DOE Program should remain focused on the reference MHTGR plant design and licensing development and supporting technology development. The primary goal of the DOE Program in FY 1987 should be to obtain a licensability statement from the NRC. This will determine at an early stage whether the NRC accepts the proposed licensing criteria, the supporting safety analyses, the technology development plan, and the overall licensing approach and role of the prospective MHTGR Demonstration Project in supporting the design certification for subsequent commercial plants. These results will be essential to the private-sector participants in the development of their commitments to the MHTGR Project. Further, the DOE Program should support the Project initiative in the development of a long-term Program/Project Plan.

Mr. Chairman, I appreciate the opportunity to present the utility/user support for and perspective on the HTGR Program to your Subcommittee. With your continued support, we will bring to fruition an HTGR Program that is responsive to utility/user needs and the Nation as a whole.

JOINT PARTICIPANTS' STATEMENT ON THE HTGR PROGRAM TO CONGRESSIONAL OVERSIGHT COMMITTEES

A secure, stable, and economic energy supply is vital to National security and economic well-being. Other developed countries have recognized that nuclear power is an important resource in providing this necessity. In particular, other industrialized countries such as Japan, Germany and France, as well as emerging industrialized countries such as Taiwan and Korea, have undertaken ambitious, sustained nuclear power programs to assure their citizens and industries the advantage of reliable, inexpensive energy; to reduce the constraints of dependence on foreign sources for essential commodities; and to foster their nuclear industries' competitiveness in the international market. Also, the Soviet Union and other industrialized socialist countries are continuing a methodical development and deployment of nuclear power for a broad range of energy applications.

The U.S. is struggling with how to revive its civilian nuclear power resources. Without presuming to offer a panacea, we point out that there is a clear need for stable licensing requirements and less onerous licensing procedures; easily understood and acceptable risks to investors and the public; and plant sizes, invested capital, and construction schedules that are consistent with current load growth and financial realities.

The Modular High Temperature Gas-Cooled Reactor (MHTGR) is well suited to fulfill these needs. Its core size and power density are limited by design such that the ceramic coatings of the fuel particles retain the fission products to an acceptable degree under all licensing basis events, with decay heat removal being accommodated by the passive mechanisms of radiation and conduction. This feature will simplify the overall concept, particularly the licensing and operations activities. In addition, safety related systems and components are minimized and are contained within a compact, standardized nuclear island. Major portions of the nuclear island can be shop fabricated and assembled to nuclear standards, facilitating enhanced quality assurance. The balance of plant is physically separated from the nuclear island and may be manufactured and constructed to conventional fossil plant standards. This will improve productivity, shorten the construction schedule and reduce field erection costs. The nuclear island is composed of independent reactor modules that can be constructed sequentially or as a cluster to more closely match load growth requirements and the utility's financing constraints. This feature will provide added flexibility and reduced financing risk that is most desirable in the current era of uncertainty for U.S. utilities' load growth forecasting.

The MHTGR is also well suited to supply high quality steam, broadening its market through cogeneration or direct steam/heat supply. In addition, the MHTGR has the unique nuclear capability for advancing to closed-cycle, gas turbine and high temperature process heat applications. Further, the MHTGR can be economically deployed on a once-through, low-enriched uranium fuel cycle and converted to fuel recycle and/or high-enriched fuel cycles as economics, facilities and policies warrant. Considering the profound potential contributions to National energy security; the investment to date and the relatively modest added investments that are required; the potential for international cooperation on the remaining development and demonstration as well as the broader international market potential, the Program participants submit that the continued development of the MHTGR is worthy of National commitment.

At the present, the MHTGR is undergoing its initial stage of design and licensing development. As a result of a thorough evaluation effort completed during FY 1985 within the DOE HTGR Program, the 350 MWt prismatic annular core, MHTGR has been established as the reference design for U.S. development and

JOINT PARTICIPANTS' STATEMENT ON THE HTGR PROGRAM (CONT'D)

near-term deployment. This concept makes maximum utilization of the HTGR technology, design and demonstration experience established in the U.S. The reference plant design adopts four reactor modules and two steam turbine generators for a nominal output of 550 MWe. The evaluations performed to date indicate the plant design can meet the performance, investment protection and economic requirements established through Gas-Cooled Reactor Associates (GCRA), the utility/user organization that supports the development and commercialization of the HTGR.

Ongoing DOE Program activities should remain focused on the development of the reference design and key technology areas to support the preparation of a Preliminary Safety Information Document by the end of FY 1986 for formal review by the NRC in FY 1987. The goal of that review is the issuance of a licensability statement by the NRC for the MHTGR. That will determine at an early stage whether the NRC accepts the proposed licensing criteria, the supporting safety analyses, and the MHTGR's technology development plan, including a demonstration project. Those results will be essential to the private-sector participants in the development of their commitments to the demonstration and deployment of the MHTGR.

As a complement to the DOE Program, GCRA, with cost sharing support from other industrial participants, has undertaken an initiative to develop a one-module Demonstration Project. Through successful demonstration of the licensing, construction, performance, costs and schedule of such a plant as well as the associated development of an industrial infrastructure, commercial MHTGR plants will become a reality. Estimates to date indicate that such a Demonstration Project, including several years of operation, would cost approximately $700 million ('85 dollars) with an additional $115 million ('85 dollars) required for supporting technology development. Without resource constraints, a Project could begin construction by 1990 and startup in 1994. Initiation of parallel commercial activity would permit commercial units to be deployed by the turn of the century.

Ongoing Project development activities are focused on detailed demonstration requirements and plans, establishment of Project management and supply entities, and the establishment of a Project Strategy Plan that will address cost/risk sharing arrangements. It is recognized and accepted that the key to the success of the Project is the ability of the private-sector participants to raise a significant fraction of the Project funds.

Crucial to the furtherance of any U.S. MHTGR Project initiative is stable Government support of the reference plant design and licensing development as well as the associated technology development that supports both the Project and long-term higher temperature applications. Accordingly, it is respectfully recommended that Congress provide $32 million for continued MHTGR development within DOE's Advanced Reactor Program in FY 1987. In addition, it is recommended that $2 million be provided to the NRC for licensing review activities. While this budget level will not support an aggressive Project schedule, it will sustain the existing resource base and communicate Program stability that will be invaluable for the continued development of the private-sector Project initiative and will foster the prospects for international cooperation. This recommendation is submitted within the context of a balanced, affordable U.S. nuclear strategy that deploys improved light water reactor systems for the near-term and maintains a development program for a long-term nuclear fuel breeder.

This Joint Statement is respectfully submitted to the Congressional Committees with oversight responsibility for the Nation's nuclear power development programs as evidence of the major participants' unified support for and recommendations on the HTGR Program.

JOINT PARTICIPANTS' STATEMENT ON THE HTGR PROGRAM (CONT'D)

R. F. Walker, Chairman, President & CEO
Public Service Company of Colorado
Chairman, Gas-Cooled Reactor Assoc.

James L. Everett, Chairman & CEO
Philadelphia Electric Company
Vice Chairman, Gas-Cooled Reactor Assoc.

E. A. Adomat, Executive Vice President
Florida Power & Light Company

C. H. Dean, Chairman, Board of Directors
Tennessee Valley Authority

J. D. Geist, Chairman, President & CEO
Public Service Company of New Mexico

Girts Krumins, President & CEO
Colorado-Ute Electric Association

George A. Maneatis, Exec. Vice President
Facilities & Electric Resources Devel.
and Pres. Elect, Pacific Gas & Electric

Robert J. O'Connor, President & CEO
Idaho Power Company

A. J. Pfister, General Manager
Salt River Project

Leroy W. Sinclair, President & COO
New York Power Authority

Harold W. Sonn, Chairman, President & CEO
Public Service Electric & Gas Company

Jack E. Thomas, Exec. Vice President
San Diego Gas & Electric Company

James E. Tribble, President & CEO
Yankee Atomic Electric Company

Bernard C. Trueschler, Chairman & CEO
Baltimore Gas & Electric Company

Keith L. Turley, Chairman & CEO
Arizona Public Service Company

K. Dance, President
GA Technologies, Inc.

William C. Drotleff, Vice President
Stone & Webster Engineering Corp.

Donald M. Kerr, Sr. Vice President
EG&G, Inc.

Donald E. Lyons, President
Power Systems Group
Combustion Engineering, Inc.

Howard Wahl, Vice President & Director
Bechtel Power Corporation

Senator DOMENICI. Thank you very much.

I think it is fair to include some other subcommittees and some other people. Obviously, we have been doing fairly well with our work as far as emphasizing these kind of programs as an authorizing committee, but I think we ought to acknowledge the excellent help that we receive in these areas from the Subcommittee of Appropriations on Energy and Water, chaired by Senator Hatfield, ranking Member Senator Johnston, and obviously, because of his genuine and abiding interest in this area, one of the senior members of Appropriations, the chairman of this full committee, Senator McClure.

In these particular areas, obviously on our side, Senate side of the Hill, they have been invaluable and we are all most appreciative of that.

I want to say, while I am not as intimately familiar with each appropriation bill as might be if I spent more time on it, I can say, however, looking at the American budget overall, that it would be, should be an embarrassment to this Nation if we are unable to support this kind of advanced technology.

With a one trillion dollar budget, to have to cancel and cut back these kinds of programs seems to me to be just the essence of lunacy. I mean, we are almost being crazy about it. These are our future.

You know, here we are running around so glad that oil prices came down, and we ought to be, and we already have studies showing that if oil prices were at $13—and it dropped so fast we do not have a current study. But if it was at $13, we would become 50 percent dependent upon foreign oil again by 1991.

We were pretty pleased to get that down to 30. That is not a terribly good set of facts, to be at 30 for a Nation like ours. But to turn right around and move in the exact opposite direction and have an absolute assurance that you are going to pass 50 percent in the next 4 or 5 years of dependence of foreign oil, and then to take the scientific and engineering capability of the country and cut it back in terms of advanced technologies for alternate energy sources seems to me to be really the height of the ridiculous.

We will do what we can. I am very pleased to say that at least the outlines provided in that budget that was approved by 70 votes will certainly accommodate—70 Senate votes from both sides of the aisle—will accommodate an increase, not a large, mammoth one, but an increase in most of the energy R&D programs over what the administration recommended.

I have no doubt that something like that will find its way through both Houses and ultimately the appropriations process.

We have a number of questions, but we are going to submit them to you to answer within the next few days. I just wanted to ask Dr. Dean, will the fact that GA Technologies has changed ownership have any impact on the development and your participation, your company's participation, in the HTGR joint effort?

Dr. DEAN. Sir, we think it is going to have a positive impact. The new owners are a private firm owned by the Blue family from Denver, CO, and they have stated that the HTGR was one of the attractive features about GA when they were arranging to submit a bid to Chevron, and they have been very enthusiastic in their

support of it thus far and I expect it is going to be a positive development for the program.

Senator DOMENICI. I am sorry that we cannot be here longer and exchange questions and views with you for a little while longer. But I am unable to do that. I have another appointment, and we are going to recess the hearings. If you would answer the questions that the staff gives you.

We will seek back that 1982 record and see if it is relevant to today, and if it is we will insert some of it as if delivered by you again today, 4 years later. Is that fair enough?

Mr. CHERNOCK. Yes, fair enough.

Senator DOMENICI. We stand adjourned.

[Whereupon, at 3:40 p.m., the hearing was adjourned, subject to the call of the Chair.]

APPENDIX V

RESPONSES TO ADDITIONAL COMMITTEE QUESTIONS

COMMISSIONERS
William E. Long
Edwyna G. Anderson
Matthew E. McLogan

STATE OF MICHIGAN

JAMES J. BLANCHARD, Governor

DEPARTMENT OF COMMERCE

DOUG ROSS, Director

PUBLIC SERVICE COMMISSION
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

May 20, 1986

Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research
and Development
Committee on Energy & Natural Resources
United States Senate
Washington, D.C. 20510

Dear Senator Domenici:

I am responding to your May 7, 1986 request to answer questions arising out of my testimony before your subcommittee on May 5, 1986. I am happy to respond and thank you again for the opportunity to testify on behalf of the National Association of Regulatory Utility Commissioners (NARUC) on the very important national issue of high-level nuclear waste disposal.

In addition to answers to these questions, I also answer one that may follow from a question you asked during my appearance. It is true that the monthly burden on a single ratepayer's pocketbook for high-level nuclear waste disposal is small; but that is a misleading indicator, an approach we recognize has been used so often that it is almost as an institution in itself.

I am aware of a rising opinion that the significant funds derived from the small current disposal assessment rates will not be sufficient to do the job. In some cases, I believe the assertion of the "small amount" is counterproductive and looked upon as the hollow promise of one spending someone else's money.

As another example of the "pennies-per-day" approach consider the agony the federal government is now suffering and that you personally are deeply involved with, the national debt. It certainly does not reflect the national concern by, nevertheless correctly, noting a desired annual debt of $100 billion equates to "only" 60¢ per hour for the average U.S. worker.

Despite the low assessment in units of dollars per unit electricity per unit of time, the total amount of funds is enormous, as you know. Yet, even at this present overall rate of expenditure of a large portion of one billion dollars per year, there is no guarantee that it will be sufficient. We are well aware of the early estimated costs of nuclear electricity in comparison with the present gloomy to disastrous costs of individual plant outputs. Furthermore, it could be that the future of nuclear power is so limited, both by public aversion and rising costs, that there will be far fewer future kilowatt-hours over which to spread future disposal costs. Finally, you and I can mentally separate out of ratepayers' bills the cost of high-level disposal, but, in fact, ratepayers cannot. They see in their bills the additional and growing charges for low-level waste disposal, added regulatory costs on nuclear plants which are sure to grow after the Chernobyl disaster, added costs for decommissioning and rising operating and maintenance charges, not to mention rising costs in the non-nuclear parts of utility operations, both in the present and the future for pollution control and ordinary costs of doing business.

While I do not wish to advance too negative a framework in which to evaluate disposal costs, it is important to recognize some of the subjective attitudes that surround this very difficult national task. My purpose is to contribute to a realistic evaluation of the disposal program and to pledge the assistance of the NARUC in contributing to a deliberate, cost-effective, safe and ultimately successful federal program.

Thank you again for the opportunity to contribute. If I or the NARUC can be of further assistance, please ask.

Sincerely,

Edwyna G. Anderson

Edwyna G. Anderson
Commissioner

Answers of Edwyna G. Anderson
National Association of Regulatory Utility Commissioners

Hearing on U.S. Senate Committee on Energy and Natural Resources
May 5, 1986

1. Q NARUC is concerned that within DOE there may be some conflict of interest between the waste management office and the Defense Program Office. Furthermore, NARUC believes that the ratepayers may end up subsidizing the disposal of defense waste. What should the appropriate amount of contributions be from the Defense program in the Waste Fund?

A The National Association of Regulatory Utility Commissioners believes that an analytical approach in which the defense and commercial programs share in the cost savings that a combined repository (or two common respositories) would produce is a reasonable approach. This approach has historical and regulatory precedence among the nation's public utility commissioners in that such a philosophy has been utilized in other traditional aspects of ratemaking. We do not, at present, promote a given value but are aware, as you are, that analysis by the Edison Electric Institute shows a value of about $10 billion as the defense share.

We must also caution that two other matters are integrally related to the matter of an exact value. First, despite our concerns that ratepayer interests have not been protected by the in camera negotiations within the Department of Energy, we will await issuance of a proposal for waste disposal cost sharing before asserting our conclusions as to total value. The second concern is that, whatever value is concluded as legitimate, it must contain several conditions that will make the defense - commercial breakdown contingent on both past and future events. These requirements for establishing and maintaining equity include

federal payment of interest on defense funds not even now deposited in the Nuclear Waste Fund that ratepayers have been paying into for over two years, assumption by the defense side of the DOE house for responsibility for future disposal program cost increases and mechanisms for cost-sharing revision in the event of changes in the amount of defense waste to be disposed of in the repository system.

With respect to the in-house negotiations within DOE, we can only hope that sufficient information is released on which to base reasoned judgment. It is true that federal finances and the national debt would be assisted by a low cost assessed for defense waste disposal and by a plan that delays defense payments to the Fund.

2. Q DOE's budget in safety research and advanced reactor concepts has been severely reduced over recent years. So has NRC's budget in reactor safety research. From both a ratepayer and a utility perspective, what impact will these cuts have on the commercial nuclear industry, both now and in the future?

A The National Association of Regulatory Utility Commissioners Subcommittee on Nuclear Waste Disposal strongly affirms its position that nuclear waste disposal success or failure should not be used as a weapon for or against the future use of the nuclear option. Too much public interest, in the form of safety, program expense and government credibility is resting on the critical need for a successful disposal program to utilize it as a political weapon.

3. Q With delay in the Nuclear Waste Program comes the increased cost. How should the Defense program share the increase in costs?

A Although we have addressed this question above, I briefly reiterate our firm view that delays, inefficiency, program redirections and other program cost increases must be shared between defense and commercial

sources in the same manner that the program's overall presently estimated cost is to be shared; and that a mechanism be established now for periodic revision, as necessary, for defense payments to the Fund.

May 20, 1986

EDISON ELECTRIC INSTITUTE The association of electric companies

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Washington, D.C. 20036-3691
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July 7, 1986

The Honorable Pete V. Domenici
Chairman
Subcommittee on Energy and Research
Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

In response to your recent letter, enclosed are EEI's responses to questions you provided pursuant to your May 5, 1986 hearing.

Sincerely yours,

Fred G. Davis
Senior Legislative
Affairs Representative

FGD:sep
Enclosure

Responses to Questions from Senator Domenici
Hearing of May 5, 1986

1.Q. In your testimony, EEI requests Congress to permit MRS acceptance of a significant quantity of spent fuel, prior to construction authorization of the first repository. What is the impact to the temporary storage of spent fuel at reactor sites if such acceptance is not permitted? And what do you think the effect will be on the first repository program if such acceptance is permitted?

A. As pointed out in our testimony, EEI/UNWMG supports the need for an Integral Monitored Retrievable Storage Facility (I-MRS) for reasons related to overall management of the nuclear waste disposal program and not the potential need for storage of spent nuclear fuel. However, an I-MRS appears to provide certain benefits in that area as well.

If I-MRS operations are not permitted to begin until the first geologic repository receives a construction authorization from the Nuclear Regulatory Commission, there would be certain impacts related to the storage of spent nuclear fuel at the reactor sites. Such a condition would link I-MRS spent fuel acceptance to the uncertainties inherent in the repository program. Therefore, no nuclear utility would be able to plan, with any certainty, on when spent fuel would be removed from their sites -- despite having signed a contract with the Department of Energy. This will serve to raise spent fuel storage costs as utilities seek to provide themselves with sufficient storage on-site so as to not impact continued operations of their plants. These costs will ultimately be borne by the electricity consumer.

It is our understanding that the need for the linkage of I-MRS operations to the construction authorization of the first repository is to demonstrate DOE's commitment to deep geologic disposal of high-level waste and spent fuel, and to prevent the I-MRS from becoming the final disposal location for these materials. We believe that DOE has demonstrated such a commitment through their actions to date, budget proposals and statements to Congress. The electric utilities have always supported deep geologic disposal for high-level waste and spent fuel. This support was recently reaffirmed when the joint Boards of Directors of the associations sponsoring the 1986 Nuclear Power Assembly* approved

* American Nuclear Energy Council
American Nuclear Society
American Public Power Association
Atomic Industrial Forum
Edison Electric Institute
U.S. Committee for Energy Awareness
National Rural Electric Cooperative Association

a resolution indicating that the first repository and the I-MRS were the first and second priority, respectively, for the DOE program from the standpoint of these organizations. Therefore, allowing the I-MRS to operate without waiting for the construction authorization for the first repository will not affect the first repository program.

2.Q. You have indicated that the defense waste share of the Waste Repository Program should be about 30% of the total waste. Could you substantiate your claim? And what do you suggest as the appropriate amount of contribution from the defense program as the cost continues to escalate?

A. As stated in our testimony, EEI/UNWMG believes that 30% is the appropriate cost share for the atomic energy defense activities to bear in DOE's implementation of the Nuclear Waste Policy Act of 1982.

The defense waste cost allocation issue has two aspects: the allocation formula and the timing of payments to the Waste Fund. There are several ways to look at this cost sharing. One suggestion being considered by DOE would base the defense waste share on the percent total curie content of waste at the time of disposal. The one mill per kilowatt-hour fee for civilian spent fuel, however, is essentially a fee on the total curie content at the time of discharge from the reactor core. Thus, an allocation based on the total curie content at disposal would credit defense waste with radioactive decay without allowing any such credit to civilian spent fuel. This would give DOE's defense programs a substantial "free ride" at the expense of electric utilities and their customers.

EEI/UNWMG believe that an appropriate cost allocation approach should be based on the primary characterization DOE utilized to justify commingling defense and civilian waste -- cost savings. Cost savings resulting from the combined operations -- compared to the overall cost of separate disposal systems -- should be shared in proportion to the cost estimate for the separate facilities. We describe this approach in more detail in an attachment to this answer.

The timing of payments into the Waste Fund for defense wastes should be comparable to commercial payments. A one-time fee, similar to that required by the utility contracts, should be paid into the Waste Fund for all defense waste generated prior to April 7, 1983 in a manner similar to the civilian payments and should appropriately include interest, again similar to the interest requirements imposed on utilities. The utilities have already made payments for pre-April 7, 1983 spent fuel of about $1.4 billion; the defense side must make a proportionate payment to ensure equitable treatment. Other fees should be paid quarterly -- according to an equitable billing formula.

3.Q. As intended in the NWPA, the central focus of the federal and States' interaction is the consultation and cooperation agreement. Why is a rulemaking on grant applications from States and Indian Tribes necessary when the Act specifically requires DOE and the States to negotiate the C&C agreement in which grant applications are part of the negotiation?

A. Regulations, adopted through rulemaking procedures, will help assure consistent, fair administration of the grant program. This will be of benefit both in cases where DOE has negotiated consultation and cooperation agreements with States and affected Indian tribes (which agreements would adopt the provisions of the regulations), and in cases where such agreements are not in place. In addition, a rulemaking will provide a broad basis for public input. This, in turn, should aid DOE in developing and establishing grant policy and procedures that best reflect the public interest.

4.Q. The consequences of schedule slippage in the Nuclear Waste Disposal Program will increase cost and erode the public confidence. What do you suggest Congress do to mitigate further program delays?

A. In the NWPA, Congress mandated target dates for major agency activities. Recently, DOE has slipped the date for recommending three sites for characterization until the end of May 1986 -- 1 year and almost 6 months after the January 1, 1985 deadline mandated by Congress in Section 112(b)(1)(B) of the Act. EEI/UNWMG is justifiably concerned that given DOE's failure to meet statutory deadlines, the first geologic repository will not be operational by the 1998 deadline. We urge Congress to intensify its oversight of DOE's implementation schedules and to require that DOE comply with Section 114(e) of the Act by notifying Congress of all schedule delays, whether caused by actions of others or by DOE's own actions, as well as DOE's plans for remedial action to overcome those delays.

Responses to Questions from Senator Domenici
Hearing of May 5, 1986

5.Q. With respect to the Uranium Enrichment Debt issue, if OMB's inclusion of the "assets," as well as the unrecovered balances, in the total debt were a valid assumption, then wouldn't it also follow that, if utilities were forced to pay for this entire "debt," that they would then become the rightful owners of the assets -- i.e., the facilities -- in the enrichment complex?

A. The "Government Investment" in the enrichment program represents equity. If the Federal Government desires to "recover" the value of this equity, it should be recovered through the sale of assets (such as enriched uranium and facilities) and through properly allocating depreciation when portions of the facilities are used. It is incorrect to reclassify "Government Investment," i.e. equity, as "unrecovered Government costs," i.e. debt, because no debt instruments were ever issued when the program was initiated, nor have any debt instruments been issued or required since as the facilities were expanded. If utilities are forced to pay for the Government's equity in the Uranium Enrichment Activity, then ownership should transfer also.

5.Q. Doesn't it make more sense to have utilities pay only the unrecovered balance, and let DOE "recoup" its investment assets by selling these assets to a private party who is truly interested in operating the enrichment complex? What is EEI's estimate of unrecovered balances that utilities still owe to the Uranium Enrichment account?

A. As previously stated, EEI does not believe that any money is owed to the Government for previously received civilian enrichment services. Sufficient data has not been made available by DOE to support a claim that civilian revenues did not cover all the expenses incurred while providing services to this class of customers. We believe that with proper allocation of the costs to the specific activities served by the uranium enrichment program it will be determined that civilian customers will have paid their full share of its costs, if not more than their share.

6.Q. Do the nuclear utilities have any control as to how their $150 million contribution to the TMI-2 cleanup efforts is being spent?

A. Both EEI and the Electric Power Research Institute (EPRI) do serve as focal points for utility input on the TMI-2 cleanup effort. The voluntary program for utility contributions for the effort is defined in Resolutions of the Edison Electric Institute Board of Directors. EEI has the responsibility to assure that the funds provided are used solely for purposes of the cleanup and that GPU provides the notices, information and cooperation necessary to carry out the program. Also, the EPRI shall, in addition to any other function it may independently perform in connection with the cleanup, advise and consult with EEI with respect to the cleanup and shall assist EEI in determining how and in what form GPU should furnish information to EEI which will be of greatest value to EEI's members. EPRI shall also consult with GPU regarding actions taken and to be taken during the cleanup, shall have access to all scientific and technical information concerning the cleanup, and shall as appropriate and necessary, physically observe actions taken during the cleanup.

7.Q. DOE's budget in safety research and advanced reactor concepts has been severely reduced over recent years. So has NRC's budget in reactor safety research. From both a ratepayer and a utility perspective, what impact will these cuts have on the commercial nuclear industry, both now and in the future?

A. DOE funding for research in association with the cleanup of Three Mile Island Unit 2 is a very important item that should be continued. That R&D component of the cleanup effort will provide important information for nuclear plant design, operation and decommissioning that ultimately will be beneficial as we proceed with the nuclear programs in this country.

Nuclear energy is required as one option to serve the future energy needs of this nation. Specific supportive effort is required by the Federal Government for the nuclear energy option to become commercially viable again. Federal programs on safety research, technology improvement and advanced reactor concepts are essential for this to be achieved. The Federal effort should be directed toward those specific tasks that have value for commercial applications.

ARGONNE NATIONAL LABORATORY
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May 20, 1986

The Honorable P. V. Domenici
Chairman, Subcommittee on Energy
Research and Development
Committee on Energy and
Natural Resources
U.S. Senate
Washington, D.C. 20510

Dear Mr. Chairman:

In your letters of May 7 and May 14, you asked for our response to several questions that arose from your Subcommittee's hearing on ~~April 29~~ May 5. I appreciate the opportunity to provide you the enclosed response, and thank you again for the invitation to testify before your Subcommittee on the nuclear fission R&D budget request.

Respectfully yours,

Charles E. Till
Associate Laboratory Director
Engineering Research

CET:vag
Enclosure

1. **You mentioned in your testimony that one of your IFR program goals is to minimize the long-lived actinide radioisotopes remaining in the waste after fuel reprocessing.**

   a. **Why is this an important goal? What are its implications in terms of waste disposal requirements?**

      a. I believe the goal is extremely important. What it meeans is that only a small fraction of the high-level waste, and preferably none of it, will be radioactively hazardous for tens of thousands of years. The current situation is that all of it is. This leads to uncertainties about geological stabilities over such long period of time, the ability of container materials to survive intact for countless years, and so on. With the actinide elements removed, the time period to decay to harmless levels drops to a few hundred years, a period of time much more within human ability to predict and design with certainty. The characteristic stigma of leaving a radioactive legacy for untold generations is removed from whole problem.

      The precise implications on waste disposal requirements will have to be clarified as the R&D shows what is possible, but the significance of the goal is very great indeed.

   b. **Where do these long-lived waste end up, if not in the waste? Are there any advantages in this over simply disposing of this waste?**

      b. The long-lived actinides will be recycled back into the reactor and destroyed. In the process, incidentally, they themselves will produce energy. The basic advantage I have alluded to above.

2. **Why can't light-water reactors, or even other types of breeder reactors besides the "IFR," survive the kinds of loss-of-flow and loss-of-heat-sink tests that you performed at EBR-II?**

   The fundamental characteristic required to survive loss-of-flow and loss-of-heat sink without scram is that the power must drop to near-zero very rapidly -- in a minute or two, say after the initiation of the accident event -- due to the natural and inherent properties of the system. LWRs and non-metallic fueled breeders inherently do not have this characteristic.

3. **Could you give us some examples of what types of experiments and what facilities are being or will be used, at FFTF Rockwell and at Argonne-West, for purposes relating to the military nuclear power programs? Are you receiving a "credit" for this work in terms of user fees to help offset your operating expenses?**

In the two high specific power reactors, FFTF and EBR-II, the main experiments that the space ractor program has currently identified are simply space reactor fuel and materials irradiations. EBR-II is currently doing essentially all this irradiation work at the present time and will continue to do so for the next couple of years. After that FFTF is expected to come increasingly into the picture. I believe, however, that the unique ability of EBR-II to subject fuels to very rapid increases in power is likely to become recognized as key to space applications likely to have just such requirements.

The SMPP, being a land-based system with far different requirements from space systems, is a different situation. The usefulness of the sodium-cooled experimental facilities will of course hinge on whether or not a sodium-cooled concept is selected. If it is, such a concept may look a lot like EBR-II. At minimum there will be a lot of common features and it is certain that EBR-II experience and expertise will be drawn on.

As for the other facilities at ANL-W, ZPPR has already performed an SMPP critical and will perform an SP-100-related critical shortly. TREAT has been occupied the past year about 50% of the time with CENTAURUS and this will continue for the next year at least.

Generally, in all these progams, the additional costs of the programs and hardware have been borne by the user, where appropriate by direct payment to Argonne. The operating costs, however, have not been offset by "user fees."

4. **Will the research needs in military areas in any way conflict with your civilian research goals? Can they be complimentary to each other?**

The research needs in the military area need not conflict with the civilian program, and certainly to the present time they have not. The point of greatest concern in changing the focus of reactor R&D to military application is that the civilian R&D itself, and the people, facilities and expertise it is based on, will be destroyed in the process. In crudest form, this would be the case if the military work were placed at Labs not now engaged in civilian work in a major way, and the civilian Labs were left unsupported.

The military reactor R&D certainly can be complementary -- the skills, expertise, and in large part, the facilities, are the same for both civilian and military. In fact, the civilian program possesses the bulk of the national resources in this area. Broadening the scope to other reactor types, if done properly with respect to institutional needs, would be natural, appropriate and complementary to the present programs, and could help in the longer term institutional survivability of the advanced reactor R&D resources of the country. It would also be the most effective for the military needs as this is where the national resources are.

5. Do you think the NRC is doing enough in its safety research program or in its licensing activities to support advanced reactor licensing efforts?

NRC working together with DOE has developed a licensability review plan for advanced reactor concepts. I understand that these review activities have been productive and are proceeding smoothly for the advanced LMR concepts. I do not see any reason to change these efforts.

Argonne (From Senator James A. McClure)

In your testimony, you refer to the fuel cycle as the "heart of any breeder system." You also note that the IFR promises "breakthroughs" in the economics of the fuel cycle, that indicate fuel cycle costs as low or lower than the LWR.

1. **What other benefits besides low fuel costs will this nation receive from the IFR concept?**

   The most important benefit of the IFR concept is almost certainly in its unique inherent safety potential. Only the IFR concept provides all the desirable inherent safety characteristics: atmospheric pressure primary system, large thermal inertia, and immunity to the most severe events the so-called called Anticipated Transients Without Scram (ATWS) event. The combination of the sodium cooling and metallic fuel enables a core design that can survive all three generic ATWS events: loss-of-flow, loss-of-heat-sink, and transient overpower. The Chernobyl accident makes even more certain that breakthrough improvements in inherent safety should be a key element of the advanced reactor development.

2. **The fuel cycle and its potential for proliferation is often seen as the "Achille's heel" of the breeder program. Does the IFR have this same vulnerability, or does this concept attempt to address this concern?**

   From safeguardability and proliferation viewpoints, the IFR concept has the following key features:

   - An integral pyrometallurgical reprocessing and remote fabrication facility is collocated and closely integrated with the reactor or reactors, thus avoiding both national and international transport of recovered plutonium and the presence and handling of sensitive material outside the reactor site.

   - The inherently limited capability of the pyrometallurgical reprocessing process employed for fission product decontamination, resulting in partially decontaminated product streams that retain significant radiation barriers to direct handling.

   These two features make the IFR substantially more resistant to diversion by subnational groups, both of an external and inside nature, than alternative reactor and fuel cycle types. This resistance results both from the reduced accessibility of the material and its reduced suitability for nuclear explosive use.

   The proliferation implications of the IFR concept can be assessed only within the technical, economic, policy and legal framework in which the technology will be developed and deployed. Thus, this issue cannot be answered as clearly at this time. It appears that there is no valid basis for concern that the development and demonstration of the IFR will be prejudical to U.S. nonproliferation interests, and considerable basis for the conclusion that it could offer nonproliferation gains over conventional breeders.

For the Second and Third Panels (5/5/86)

1. **One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications, is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular R&D program.**

   To the present time the only focus of proposed SDI reactor development is on space-based nuclear reactors as suppliers of energy. Space nuclear reactor systems have very different requirements than land-based civilian systems. The principal requirements not shared by civilian systems are compactness and high temperatures. These set the designs and the materials that it is possible to use. Unusual, exotic, and as a rule, expensive materials are necessary. There can be little carry-over to civilian technology where the objective is economic electrical power. Therefore I cannot agree that such technology will have significant application to the civilian reactor area.

2. **The development of a second generation of nuclear plant designs -- simplified licensable designs which are inherently safer that current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?**

   I fully agree that the development of a second generation nuclear plant with inherent safety characteristics is essential to the success of an improved NRC licensing regime, as well as to the revitalization of the nuclear energy. Evolutionary improvements on existing nuclear plants would not change the licensing regime. A new generation reactor concept with revolutionary breakthroughs in inherent safety could well help to shape an improved licensing regime.

3. **Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR and HTGR (indiviudal panelists should respond regarding reactor with they they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?**

   The IFR concept is still in R&D phase. Technology development, particularly in fuels and pyroprocesses, is laid out for the next three years. It is anticipated, under the requested funding levels, that the practicality of the entire IFR fuel cycle will be demonstrated in five years, including two years of operational demonstration, at which time the IFR concept can be evaluated for full scale plant deployment. The timetable for NRC certification must follow the schedule of the plant project or the demonstration project.

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May 20, 1986 In reply refer to 86RC06901

Senator Pete V. Domenici
Chairman, Subcommittee on
Energy Research and Development
United States Senate
Washington, D.C. 20510

Dear Senator Domenici:

I appreciated the opportunity to testify before your Subcommittee on May 5, and I am also happy to be able to provide answers to the questions in your letter of May 7 for the record. The answers are enclosed in a question-answer format.

If you have any additional questions, or if I can help you in any other way, please let me know.

Very truly yours,

John S. McDonald
Director
Atomics International

7183A/bjm

Enclosure as stated

Enclosure
86RC06901

RESPONSES TO QUESTIONS FROM SENATOR DOMENICI

Question 1

Could the SAFR be licensed under current NRC regulations, or would the NRC have to develop a new approach to its licensing process in order to accommodate advanced reactors such as SAFR?

Response

The SAFR can be licensed under current NRC regulations. As for the Clinch River Breeder Reactor Plant (CRBRP), the NRC would have to interpret some of the current regulations and regulatory guides as to applicability to LMRs. This interpretation is required because of inherent differences between water and sodium-cooled reactors. The NRC may consider some of these new interpretations as "policy" changes.

Question 2

Based on your interactions with Defense and SDI personnel, do you feel these people have a sufficiently detailed idea of their needs and operating criteria for companies like yours to be able to effectively develop and deliver military reactor power plants to meet their needs? Do you feel that the defense program people know what they want? Are they a truly interested "customer" for reactor power applications?

Response

The Air Force, working with the DOE, has established a concise set of requirements for the Multimegawatt Terrestrial Power Plant (MTP). These requirements have been incorporated into the Request for Proposal which requests fixed-price bids.

The U.S. Army Strategic Defense Command is in the process of formulating the needs and requirements for ground-based SDI power. They plan to quantify their requirements by the end of the fiscal year. They recognize that large amounts of secure power will be required for future weapons systems, but additional studies will be required to determine the best methods of providing the power.

The Air Force, through the MTP Program, is truly a "customer" for reactor power systems. The SDI is very interested in the reactor power option, but we will need to work closely with them to determine if reactors constitute the best method of providing the power to meet their needs. Studies performed to date show that reactor power plants have very favorable characteristics for the SDI applications.

Question 3

Do you feel that any portion of the 60% cut in DOE's Advanced Reactor R&D budget will be offset by the work you and other labs will be able to pursue in military applications concurrent with, and hopefully in parallel with, your civilian reactor research work?

Response

We do not anticipate that work in the area of military applications will significantly mitigate the adverse effects of the 60% cut in DOE's Advanced Reactor R&D budget in FY 1987.

If the liquid metal reactor (LMR) concept is selected for the MTP, it would provide a means of retaining capabilities in the face of the budget cut, but the work being performed would not be directly applicable to the civilian reactor program.

The design of a SAFR-type reactor for SDI applications would have many features similar to those required for a civilian power plant, but it is not expected that the SDI will be funding any design studies in FY 1987.

Question 4

Is your SAFR liquid-metal reactor design amenable to the incorporation of the inherent safety features of Argonne Integral Fast Reactor (IFR) concept? Describe your working relationship with Argonne in terms of integration of ideas and concepts.

Response

Yes, the reference SAFR approach does incorporate the IFR. In fact, ANL has used SAFR as the reactor model in many studies they have made of the integral fuel cycle concept.

Until very recently, the SAFR design was based on the use of either oxide fuel or metal fuel which forms the basis for the Argonne Integral Fast Reactor (IFR) concept. The primary reason for retaining the oxide fuel was the greater data base available. However, use of metal fuel provides a much more economical means of attaining inherent safety. Based on the continued success of the IFR program, we have now adopted metal fuel as our reference, with a derated oxide fuel as a backup in the event that future test results fail to substantiate the promise of metal fuel.

Rockwell has worked closely with Argonne of LMR work for several decades. In the last few years, the working relationship has been extremely close, starting with the Large Pool Plant (LPP) design which developed into SAFR. Argonne has essentially been a team member on these projects, participating in tradeoff studies and design reviews as well as providing design inputs in their areas of expertise. They have provided both core and system transient analyses. ANL also participates in all project coordination meetings and participates in discussing the commercial as well as technical aspects of the project.

Question 5

Are you planning any tests of SAFR technology concepts at the Argonne or FFTF facilities? Please describe these.

Response

Yes. The tests planned are:

1. Pump Tests

   Fabricate a 6,000-gpm scale model of the SAFR pool inducer pump, and do water tests at ETEC and then install it in the EBR-II secondary loop. Verify startup and coastdown characteristics, hydraulic performances, and endurance capability.

2. Steam Generator Test

   Install a scale model SAFR hockeystick steam generator with heat transfer enhancement in EBR-II or ETEC. Verify design and off-design performance, determine stability limits, and endurance behavior.

3. Anticipated Transients Without Scram (ATWS) Tests

   Extend the highly successful loss of heat sink and loss of flow without reactor scram test series at EBR-II to include transient overpower tests without scram to conclusively demonstrate the inherent safety characteristics of liquid-metal reactors. Perform similar tests using the higher power FFTF to reduce the uncertainty in the large safety margins predicted for the SAFR.

4. Self-Actuated Shutdown System (SASS) Tests

   Feature tests are being done at ETEC. When these are completed, perform inherent shutdown tests in either EBR-II or FFTF using a scale model of the SAFR SASS. Demonstrate the inherent response of the curie point magnet and absorber insertion response time.

5. Decay Heat Removal Tests

   We are doing decay heat removal tests at ETEC. We will also perform out-of-pile tests on a full-scale sector simulation of the SAFR inherent reactor auxiliary cooling system (RACS) at Argonne East. Simulate the air-side cooling of the RACS system. Verify the performance characteristics under all conditions including the large tolerance to aerosol deposition on cooling surfaces.

6. Integral Fast Reactor (IFR) Test Program

As discussed previously, the IFR approach is a major element in the reference SAFR concept. Therefore, the proposed program should be completed using the Argonne and FFTF facilities.

7. Core Critical Experiments

Perform SAFR core critical experiments at the Argonne ZPPR facility.

8. Nuclear Instrumentation

Verify performance of high-temperature neutron detectors and high-frequency leak detection (HALD) system using the EBR-II facility, and on the ETEC steam generator.

9. Plenum Hydraulics

Verify the hydraulic performance of the SAFR reactor plenum using the ANL East water test facility.

Question 6

Is there any foreign interest in or interaction with you in terms of your SAFR design or your facilities capabilities at your Energy Technology Engineering Center?

Response

Rockwell has had a strong working relationship with Japan's Kawasaki Heavy Industries (KHI) through a technology exchange agreement in effect for the past 15 years. KHI is currently developing inducer pump and booster tube steam generator technology in Japan based on the concepts developed for SAFR by Rockwell. In addition, KHI has arranged seminars for disseminating SAFR information to Japanese utilities and continues to publicize the advantages to Japanese audiences. There is evidence that the Japanese have a significant interest in ETEC capability.

We are currently in the process of developing with KHI a plan for a combined cooperative U.S.-Japan and totally Japanese-funded R&D program using ETEC facilities. We have conducted tours of the facilities for a great number of Japanese LMR experts over the past few years, and they are quite impressed with the capabilities and appear ready to reach agreements to utilize same.

The Japanese Power Reactor and Nuclear Fuel Development Corporation (PNC) has had strong interest and interaction with the Energy Technology Engineering Center (ETEC) over the past 10 years. This interaction has consisted of DOE agreeing under an international exchange agreement to have continual representation of PNC at the ETEC site. PNC has also sponsored component testing at ETEC, and they are currently discussing with DOE the potential for significant involvement in future steam generator testing activities.

Question 7

In your view, is nuclear licensing reform a critical element in successful deployment of SAFR in the utility marketplace?

Response

Yes. As long as the licensing process is dependent more on the ability of interveners to obtain delays through legal manipulations rather than on the merits of the design, and the NRC is not required to justify changes on a cost benefit or some other objective basis, there will be a substantial delay in successful deployment of the SAFR.

Question 8

What kind of private/federal partnership do you think is feasible for prototype testing and license certification of the SAFR concept?

Response

The federal/private partnership currently envisioned for the SAFR prototype is a unique joint venture between utilities, vendors, and the government that supports the testing, licensing certification, and productive operation of the SAFR prototype. Its uniqueness comes from the concept of a prototype that has a commercial economic value. Since the prototype will be a full-scale, 350-MWe SAFR power plant, it will have the ability to produce an estimated 2,606 million kilowatt hours of electricity per year. At 40 mills per kilowatt hour, the SAFR prototype, operating in a commercial mode, would have an income stream potential of over $100 million per year. For the nominal 30-year life of the plant, this represents a total economic value of over $3 billion. Part of these funds would be available to return the investment made by the participants and provide appropriate economic incentives to insure the success of the project.

Question 9

Could you give us some examples of what types of experiments and what facilities are being or will be used at FFTF, Rockwell, and Argonne-West for purposes relating to the military nuclear power programs? Are you receiving a "credit" for this work in terms of user fees to help offset your operating expenses?

Response

For the SAFR application to the SDI, the only additional experiment envisioned is to verify the rapid startup capability of SAFR. Simulation experiments using EBR-II should provide this verification.

For the MTP Program, several demonstration-type experiments as well as use of production facilities are anticipated, such as:

1. A natural convection core barrel thermal baffle test at the ETEC LMDL facility.

2. Reactor system hydraulics tests at the ETEC hydraulic test facility.

3. Reactor core critical tests at the Argonne ZPPR facility.

4. Fuel fabrication using the HEDL secure automated fuel (SAF) line.

The laboratories will receive "credit" or user fees to offset operating expenses.

Question 10

Will the research needs in military areas in any way conflict with your civilian research goals? Can they be complementary to each other?

Response

No conflict is anticipated between the research needs of the military and civilian reactor programs. If substantial military research funding were provided to support the development of a SAFR-type reactor power plant, most of the work would be directly complementary to the civilian reactor development program.

Question 11

Do you think the NRC is doing enough in its safety research program or in its licensing activities to support advanced reactor licensing efforts?

Response

The current NRC research program is adequate. However, it is important for the NRC to have available experts from the national laboratories to support their reviews of advanced designs. An effective way to assure expert availability is to bring them in during the prelicensing reviews of the advanced reactors.

The cutback in NRC support to the advanced reactor licensing effort has crippled this activity. For review of the two advanced LMRs and the HTGR, we would estimate that a minimum effective level of support would be 6 to 7 people at NRC plus 4 to 5 people at the national laboratories, on a full-time basis.

5168B/slw

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May 27, 1986

In reply refer to 86RC07168

Senator Pete V. Domenici
Chairman, Subcommittee on
Energy Research and Development
United States Senate
Washington, D.C. 20510

Reference: Rockwell Letter 86RC06901 dated May 20, 1986

Dear Senator Domenici:

I am happy to be able to provide answers to the additional questions in your letter of May 14 to supplement those in the referenced letter. The answers are enclosed in a question-answer format.

If you have any additional questions, or if I can help you in any other way, please let me know.

Very truly yours,

R. D. Oldenburg for

John S. McDonald
Director
Atomics International

7183A/emh

Enclosure as stated

Enclosure
86RC07168

Responses to Questions for the Second and Third Panels

Question 1

One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular R&D program.

Response

We do not agree that Strategic Defense Initiative (SDI) research will have significant applications in the civilian reactor area. The SDI applications which have been identified to date (Multimegawatt Terrestrial Power Plant and Space Reactor Power Systems) all require small, highly specialized reactors. Research and Development on these reactors will help the civilian reactor area only slightly, if at all, by spinning off any new developments which are applicable to reactors in general.

If ground-based SDI requirements are identified which require power levels equivalent to those from civilian reactor modules, R&D on these power systems could have direct application to the civilian reactor program.

Question 2

The development of a second generation of nuclear plant designs--simplified licensable designs which are inherently safer than current reactors--would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?

Response

We agree. There appear to be two prerequisites to a successful preapproved standardized design concept: a predictable short licensing process and a long "shelf life" of the resulting certified design. The advantageous characteristics of a simplified inherently safe design should be easy to demonstrate and

understand and, therefore, easily and predictably licensable. The safety of advanced LMRs, due to their inherently safe features, is insensitive to events occurring in the balance of the plant or operator error. Therefore, it is very unlikely that significant design changes that would effectively invalidate the certified design would be imposed due to unfavorable experiences on current or future reactors.

Question 3

Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR, and HTGR (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

Response

Assuming the Administration requested level of funding through FY 1992, the first SAFR could be licensed and operating and certification of the standard SAFR design could be achieved in the year of 2000. This assumes a down selection to SAFR by the end of CY 1988 and a focusing of LMR R&D on metal fuel and the few remaining key areas in support of the SAFR plant.

On the other hand, certification could be obtained by 1997, assuming the levels of advanced LMR funding in the original SAFR and PRISM contracts and the funding for the limited R&D necessary to support the SAFR plant. It was also assumed that there would be a down selection to the end of CY 1987, and starting in FY 1988, the DOE funding would be stepped up to about $40 million per year through preliminary and detailed design.

7183A/emh

GENERAL ELECTRIC

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J. S. ARMIJO MANAGER
NUCLEAR SYSTEMS TECHNOLOGY OPERATION
NUCLEAR TECHNOLOGIES & FUEL DIVISION

May 16, 1986

Senator Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
United States Senate
Washington, D.C. 20510

Dear Senator:

On behalf of the General Electric Company I wish to thank you and your subcommittee for the opportunity to present testimony on May 5, 1986 regarding DOE's FY 87 nuclear research and development programs. Our responses to your follow-up questions are attached per your request.

On a personal note, I very much appreciated your interest regarding my family history in New Mexico. While I cannot claim to be a native of New Mexico, I am well aware of its beauty, history, culture, and most importantly its outstanding food. A copy of my curriculum vitae is also attached for your information.

Sincerely,

J. S. Armijo

da

Att.

GENERAL ELECTRIC RESPONSE TO FOLLOW-UP QUESTIONS TO MAY 5, 1986 HEARINGS

BY THE SUBCOMMITTEE ON ENERGY RESEARCH & DEVELOPMENT

OF THE SENATE COMMITTEE ON ENERGY & NATURAL RESOURCES

1. What type of industry/government cooperative program do you envision to proof-test a prototype PRISM reactor and certify its licensability? How much of the "burden" do you think the government should bear in such an effort?

   We believe the United States government must accept the responsibility and provide the leadership and resources necessary to prove the PRISM reactor's self protection capabilities. Once this is accomplished, the private sector must accept the responsibility for certification and commercialization. With an established program and government commitment for a safety test of the reactor's self protection features, we expect increased potential for private sector financial participation.

   There is a successful model for such an approach. In the late 60's to early 1970's the Southwest Experimental Fast Oxide Reactor (SEFOR) was built and operated by General Electric in cooperation with the United States Atomic Energy Commission, 13 U.S. utilities, and the Karlsruhe Nuclear Research Center of West Germany. This landmark project demonstrated the inherently safe response of oxide fueled, sodium cooled, fast reactors to super prompt power transients. The SEFOR Project confirmed predictions that the Doppler effect would passively protect the plant in time periods of tenths of a second, far faster than an active electrical mechanical shutdown system could respond. This conclusive safety test achieved worldwide acceptance of the Doppler effect as an inherent passive safety feature of these reactors and is no longer a licensing issue. We believe a similar project is the appropriate approach for a proof test of the inherent safety of a prototype PRISM reactor for normal design basis events, and beyond design basis events such as complete loss of primary coolant pumps without scram, complete loss of all active heat rejection systems without scram and control rod withdrawal without scram. The safety test would show that PRISM would passively shut itself down and cool itself in all of these very low probability events.

2. Is your PRISM reactor design adaptable to Argonne's IFR (Integral Fast Reactor) concepts, in terms of walk-away safety and simplicity?

   The IFR technology features (a pool reactor, metallic fuel, and pyrometallurgical reprocessing) are included in the PRISM reactor design. In addition to a reference core design based on metallic fuel, PRISM includes several unique features to protect the safety of the public and the plant investment. For example passive decay heat removal from the PRISM reactor is accomplished by PRISM's radiant vessel auxiliary cooling system. This system utilizes natural circulation of sodium within the reactor vessel and natural air circulation over the containment vessel to maintain the reactor at temperatures below damaging levels for all postulated accident events. PRISM is unique in its use

of passive seismic isolation of the entire reactor assembly. This minimizes the impact of earthquakes on the reactor and improves its licensing and siting flexibility. PRISM is unique in its use of double wall steam generators which protect the reactor from the threat of sodium water reactions and improve plant availability. The 20 year successful performance of the EBR-II double wall steam generators attest to the effectiveness of this design. Overall, the IFR technology features and the above design features are central to PRISM's walk-away safety, operability and economics.

3. Are the European and Japanese showing increasing interest in your PRISM design?

   Growing foreign interest in the PRISM design is evidenced by recent papers in European and Japanese technical journals. In addition Japan's Central Research Institute for the Electric Power Industry (CRIEPI) has carried out a preliminary assessment of PRISM regarding its potential in Japan. We would expect foreign interest to increase significantly if a U.S. decision was made to proceed with a PRISM reactor safety test project.

4. Are NRC's current licensing requirements compatible with advanced reactor concepts?

   The advanced reactor concepts could be licensed and constructed under NRC's current licensing requirements. However, past experience with the licensing of light water reactors indicates that there is a great deal of uncertainty and cost associated with the current approach. We believe there is a more direct approach to the licensing of passively safe modular reactors that not only provides the information required by the NRC but also provides a means of demonstrating the reactor's passive safety and gaining public and utility acceptance. Because the PRISM reactor is small, a test of a single full size module that demonstrates the safety of the system and the protection of the investment is both practical and affordable. With such a safety test of PRISM, we believe we could gain NRC certification, public acceptance and a firm basis for an economically competitive power generation system. To this end, General Electric has introduced to the Department of Energy and the Nuclear Regulatory Commission a proposed Appendix S to the NRC's licensing regulations which recognizes and permits the certification by test approach for advanced reactors. Preliminary responses from NRC management to this initiative have been positive. A recent letter from the NRC describing its interest is attached.

5. What facilities at FFTF, Argonne, or ETEC are you utilizing for proof-of-concept testing of your PRISM reactor design?

   General Electric is making extensive use of government facilities in the development and testing of PRISM subsystems and components. For example, the EBR-II operated by Argonne National Laboratory at INEL has conclusively demonstrated the passive safety characteristics of metal fuel and will be used in the future to demonstrate advanced control technologies for PRISM. Early tests of PRISM's passive air cooling concept were successfully performed at HEDL's FFTF facility. Additional

safety performance characteristics related to PRISM's shutdown heat removal are being demonstrated at ANL-E with water simulation tests of the reactor and a full height segment of the natural circulation air cooling system of the reactor. The design of the PRISM's innovative electromagnetic pump will be verified at the Energy Technology Engineering Center. Additional R&D tasks emphasizing design simplification, inherent safety enhancement and modular component development have been identified and are in progress at the National Laboratories.

In the future, the facilities and work force at the Argonne National Laboratories, Idaho Nuclear Engineering Laboratory site will be ideally suited for the proposed PRISM reactor safety test. Existing facilities and equipment such as reactor servicing, fuel fabrication and control rooms may be directly applicable. The combination of the PRISM reactor safety test and the demonstration of the closure of the metal fuel cycle with HFEF and PRISM operating in concert would effectively resolve the key issues (excessive plant costs and excessive fuel cycle costs) currently limiting the commercialization of liquid metal reactor technology.

6. Do you think the NRC is doing enough in its safety research program or in its safety research program or in its licensing activities to support advanced reactor licensing efforts?

The NRC has very recently reduced its FY86 efforts and plans to reduce its FY87 efforts below the level required to conduct the necessary early interactions on advanced reactor designs. These reductions will not leave sufficient resources to complete the Preliminary Safety Information Document (PSID) reviews that were planned as the focal point of these early interactions. The NRC staff reviews were relying on laboratories and outside technical consultants to support the PSID reviews. These people are needed to supply independent analyses that the staff is not able to perform itself because of the sophisticated computer codes and methods employed. These are not developmental but their application requires laboratory staff who have been involved in the technology development. The advanced reactor concepts being developed do not require any new NRC safety research because they are based to a large extent on existing technology. Congressional budget support for the NRC aimed at early interactions on advanced reactor designs is warranted.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 08 1986

Glenn G. Sherwood, Manager
Safety and Licensing Operation
Nuclear Energy Business Operations
General Electric Company
175 Curtner Avenue
San Jose, CA. 95125

SUBJECT: NRC CERTIFICATION OF ADVANCED NUCLEAR POWER PLANT DESIGN

Dear Mr. Sherwood:

Your letter of March 7, 1986, summarized recent discussions between our staffs on the use of a prototype test reactor to demonstrate performance and to be used in the certification of a standard design. A draft proposed rulemaking addressing the use of a prototype test was also presented.

The objective of utilizing demonstrated performance through safety test results in a certification process appears to be an innovative approach to licensing that is consistent with the Commission's proposed Policy for Regulation of Advanced Nuclear Power Plants (50FR 11882). Even though recent budget constraints have caused us to reduce our effort on advanced reactors we plan to continue some interaction in the advanced reactor area and are in the process of discussing with the Department of Energy (DOE) plans for these future interactions. We consider your proposal regarding the application of safety test results to a certification process to be an important consideration for advanced reactors with the potential for improving the licensing process and, as such, warrants further interaction between our staffs.

In closing let me say that I support the innovative thinking your company has shown in proposing this licensing approach. I have asked Dr. Themis Speis of my staff to consider your initiatives in planning future activities with the DOE. If you have further comments or questions please contact Dr. Speis at (301) 492-7517.

Sincerely,

Darrell G. Eisenhut, Acting Director
Office of Nuclear Reactor Regulation

cc: J. Vaughan, DOE

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY
310 DEGUIGNE DRIVE
P.O. BOX 3508
SUNNYVALE, CALIFORNIA 94088

J. S. ARMIJO MANAGER
NUCLEAR SYSTEMS TECHNOLOGY OPERATION
NUCLEAR TECHNOLOGIES & FUEL DIVISION

May 27, 1986

Senator Pete V. Domenici
Chairman, Subcommittee on Energy
Research and Development
United States Senate
Washington, D.C. 20510

Dear Senator:

Attached are my summary answers to your follow-up hearing questions. If additional detail is required, I would be pleased to provide it to you.

Sincerely,

P R Pluta for J S Armijo

J. S. Armijo

/da

Att.

QUESTIONS IN FOLLOW-UP TO HEARING BEFORE
SENATE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
ON CIVILIAN REACTOR PROGRAM HELD MAY 5, 1986
AND GENERAL ELECTRIC NUCLEAR SYSTEMS TECHNOLOGY OPERATION ANSWERS

1. One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications, is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular R&D program.

   We believe that the civilian nuclear research program and research on military (Strategic Defense Initiative) applications are complementary programs. Technology developments in either program can benefit the other. For example, the nation's ability to rapidly develop a reference design for the SP-100 project was the direct result of a continuing and strong civilian nuclear program in the areas of liquid metal fast reactor technology, and thermoelectric power conversion technology. In addition, the availability of the Department of Energy's National Laboratory organizations and facilities to perform early scoping tests and analyses were and continue to be extremely important to the progress of the SP-100 program. We anticipate that technological developments in support of military programs will ultimately have spin-off benefits to the civilian nuclear program, but it is difficult at this time to assess the extent of such benefits.

   Despite the complementary nature of the two programs we do not believe the civilian nuclear research program should be reduced in order to fund research on military applications. While we envision no near term technology benefits from the military research program to the civilian nuclear research program in the near future, past experience with light water reactor technology has shown that such benefits will ultimately become available. While technology developments are complementary, system designs are unique to the particular requirements of the two programs. Since specific criteria and priorities for nuclear systems designed for military applications are substantially different from those systems designed for civilian applications it is probable that specific system designs will be limited to their own specific programs. Thus while technology benefits can flow between these two programs, system designs will remain unique.

   There is a less visible benefit to the civilian nuclear research program from the planned growth of the military program. For several years the decreasing civilian nuclear program has had the sole obligation of funding the nation's nuclear power focused national laboratory facilities. Over the last few years operating costs of these facilities have become a dominant factor in the total civilian nuclear research project, and have limited the program's ability to perform other highly

important design and development activities. Since the military program will utilize and benefit from these National Laboratory facilities we anticipate that some of the base costs for their operation will be borne by the military program and will improve the flexibility of the civilian reactor program to perform its mission.

2. The development of a second generation of nuclear plant designs -- simplified licensable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the pre-approved standardized design concept. Do you agree with this statement? Why or why not?

We do not agree second generation nuclear plant designs are essential to gain a pre-approved standardized NRC license. This can be achieved with Light Water Reactors by utilizing past experience and incorporating evolutionary design changes as appropriate. Worldwide experience has shown that U.S. light water reactor designs based on active safety systems and defense in-depth concepts are safe and licensable. However, the costs and financial risks associated with constructing such plants in the U.S. have become prohibitive. The objective of the recent advanced reactor designs is to meet the safety goals required by the NRC for Light Water Reactors and reduce plant costs by designing these systems on the basis of passive safety and defense in-depth.

GE's innovative Liquid Metal Reactor (PRISM), approaches licensing by concentrating on passive safety based on inherent characteristics of the fuel, the coolant and the system, and by proving the systems by performing conclusive safety tests on a full size reactor module.

3. Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR and HTGR (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

The Administration funding request for NRC certification of the ALWR is sufficient to proceed toward this goal and achieve certification in the early nineties. The LMR request is insufficient to complete the technical and economic assessment of the innovative LMR concepts as originally planned for FY87. Until this program is completed and selection of a concept is made that leads to a commitment to proceed with a reactor test, a date for LMR certification is difficult to establish.

Certification of an advanced LMR such as GE's PRISM reactor could be expected by 1996 if FY1987 funding for the innovative LMR's is provided as requested in our testimony, and if DOE implements a process to select a specific design for a reactor test project during FY87/88 and initiates Title 1 design activities in FY1989

Westinghouse
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Advanced Power
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W H Arnold
General Manager
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Division

Box 158
Madison Pennsylvania 15663

May 19, 1986

The Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research and Development
United States Senate
Dirksen Senate Office Building - Room 434
Washington, D. C. 20510

Dear Senator Domenici:

I presented testimony before your Subcommittee on May 5, 1986 in the area of Policy Oversight of DOE's FY87 nuclear research and development programs. You requested my written response to a set of follow-up questions. I am pleased to provide my response to the questions in your letter dated May 7, 1986.

Sincerely,

W. Howard Arnold

Attachment

Responses to Questions from Senate Subcommittee
on
Energy Research and Development

1. What kind of interest is being shown by Europe or Japan in the work you are doing at FFTF on long-life cores? Is there any possibility of international collaboration work in this area to help leverage the DOE budget?

   Response:

   There has been considerable international interest expressed in the work on long-life cores and the associated development of improved cladding materials, both from Europe and Japan. There is already in place an agreement with Japan for collaborative testing of long-life fuel and blanket assembly designs in FFTF, with the tests scheduled to be installed in the FFTF core in late 1987. Further development of this system on a joint basis is possible; DOE action would be required to proceed with arrangements for expanded collaboration.

2. What plans do you have to subject FFTF to the same kinds of loss-of-power or loss-of-heat-sink tests that were done at EBR-II? Do you expect similar results?

   Response:

   The HEDL Inherent Safety Program includes a series of tests to demonstrate performance characteristics of FFTF during an unprotected loss-of-flow event. These tests will be similar in nature to the loss-of-(site) power or station blackout simulation recently performed at EBR-II. The first FFTF tests are planned for July 1986; they will be performed from initial power levels as high as 200 MWt (50% of full power). Pending results of the July 1986 tests and the installation of an instrumented fuel assembly in FFTF, we plan to perform a series of loss-of-flow-without scram (LOFWOS) tests from full power (400 MWt) in May 1987.

   In these tests, we expect to get results similar to those obtained in EBR-II. Both EBR-II and FFTF are liquid metal reactors and have many similar characteristics; however, there are a few important differences between the two reactors. FFTF has a mixed oxide fuel system which provides a larger Doppler effect than the metal fuel system used at EBR-II. The larger Doppler effect is a safety advantage for most considerations. However, in a LOFWOS event, this larger Doppler effect would result in higher fuel cladding

temperatures unless a passive safety enhancement system were to be installed. HEDL has developed a simple passive "manometer" assembly, known as GEM (Gas Expansion Module), which adds negative reactivity any time the primary system flow decreases. The use of the GEM system in the oxide fueled FFTF or in small innovative plants would result in satisfactory cladding temperatures for the LOFWOS transient.

Planned passive safety testing in FFTF does not presently include loss-of-heat-sink-without-scram testing. The results of innovative LMR design studies indicate that other off-normal events are more important and bound the consequences of a loss-of-heat-sink-without-scram. Hence, we are placing our emphasis and programmatic resources on loss-of-flow and transient overpower events.

3. What kind of working relationship do you have between your FFTF facility and GE or Rockwell in terms of development of advanced liquid metal reactors? What can you contribute, in terms of facilities or expertise, to these research efforts?

Response:

Within one month of the time that DOE contracts were awarded to GE-NSTO and Rockwell International for the design of advanced liquid metal reactors (LWRs), Westinghouse Hanford Company established a program overlay organization with the responsibility for coordinating designer requirements with LMR development at FFTF and its supporting facilities. During FY1985, support was provided in the form of FFTF operating experience, system design reviews and consultation, and FFTF test program results. A total of 54 design-specific information items were furnished to GE-NSTO and RI. During FY1986, our work scope contains 92 deliverables requested by the designers, all of which we expect to provide on schedule. We have frequent contacts with both GE-NSTO and RI, both informally and as structured review meetings and we provide periodic reports. Westinghouse Hanford Company considers the working relationships with both designers to be excellent and appreciates the interaction with them.

The DOE Technology Support programs at the Westinghouse Advanced Energy Systems Division (W-AESD) have also been redirected to support the DOE innovative designs of GE and Rockwell International. A number of design features and concepts pioneered by W-AESD are included in those designs.

4. What was FFTF's role in the breeder community prior to termination of Clinch River? What is its role now?

Response:

The FFTF is the only reactor in the U.S., in fact in the world, with the primary mission of developing and testing full-size prototype LMR core components. Prior to the termination of the CRBRP Project, the performance of FFTF core components and tests was directly supportive of the CRBRP design and a number of tests of CRBRP prototype core components were underway. Currently, FFTF is being used to develop long-lifetime oxide fuel and blanket components to meet identified innovative designer needs. A similar program for metal fuel and blanket components, supportive of evolving innovative designer needs, is being formulated. New testing programs are emerging in support of space and terrestrial strategic defense applications.

5. In your testimony, you indicated you are working with Japan on an advanced pressurized-water reactor design. Would this design be attractive to utilities in this country? What are your plans to seek licensing approval of this design in the U.S.? Is licensing reform a necessary prerequisite for successful deployment of this design in the U.S.?

Response:

Yes, our Advanced Pressurized Water Reactor (APWR) design is attractive to utilities in this country. The principal improvements in the design should be equally attractive to Japanese and U.S. utilities. These improvements include:

- Longer fuel cycle times that increase availability and reduce occupational radiation exposure.
- Improved, more corrosion resistant steam generators that require less maintenance and reduce occupational radiation exposure.
- Simplified fluid and electrical systems reduce space, equipment, piping and wiring requirements, and therefore construction costs.
- A moderator control system that will substantially reduce fuel cycle costs.
- Reduced core specific power and increased coolant inventory above the core that provide larger design margins.
- An improved Emergency Core Cooling System that ensures the core will remain covered for off-normal conditions.

Westinghouse, at its own expense, is obtaining regulatory approval of the APWR from the NRC. We have involved the NRC and the ACRS early in the design process and have solicited the views of U.S. utilities as well. We expect to complete our application for Preliminary Design Approval by mid-1986.

We believe that licensing reform is a necessary prerequisite to the successful deployment of any design in the U.S. in the future. Our utility customers require assurance that plants can be built on a reasonable schedule and at a competitive cost. Licensing reform to reduce the uncertainties associated with changing regulatory requirements is vital to this process.

6. Your work with Japan on an advanced light-water reactor design involves interaction with Japanese utilities. Are you working with domestic utilities to determine U.S. - specific needs for future nuclear plants?

Response:

Yes, we are working with U.S. utilities to determine their needs for future nuclear plants. We have found that the improved features being designed into the APWR are attractive to U.S. utilities as well as Japanese utilities. As discussed in the response to Question 5, we are in the process of obtaining NRC approval for the design. We believe the design will find acceptance in the U.S. when the domestic market for nuclear plants returns.

7. Could you give us some examples of what types of experiments and what facilities are being or will be used, at FFTF, Rockwell and at Argonne-West, for purposes relating to the military nuclear power programs? Are you receiving a "credit" for this work in terms of user fees to help offset your operating expenses?

Response:

Experiments in FFTF relating to military nuclear power programs fall into two categories, materials and fuels. Sheath insulator materials irradiation, a part of the Thermionic Fuel Element (TFE) development program, will begin in September 1986 and the first of several SP-100 fuel tests will begin irradiation in early 1987. Testing of this kind is expected to continue through 1991. No "credit" is being received in FY1987 to help offset FFTF operating costs, although part of the experiment fabrication facilities costs will be charged to the military nuclear power program. Beginning in FY1988, we are expecting to receive "user fees" from the military nuclear power program to help offset FFTF operating expenses, as well as those incurred by experiment fabrication and examination facilities.

8. Will the research needs in military areas in any way conflict with your civilian research goals? Can they be complementary to each other?

Response:

Research needs in military areas would only conflict with our civilian research goals from the standpoint of financial resource allocation. If financial resources are allocated to the military areas at the expense of the civilian area, the civilian research goals will not be met. From the standpoint of use of facilities, we do not see a potential conflict. For example, in the case of FFTF, the reactor is sufficiently large and flexible to accommodate a multiplicity of test programs. Procedures are in place for effective resolution of potential conflicting test requirements, and no problems are foreseen. The programs can be complementary through a broadening of the base of support for the operation of important test facilities such as FFTF.

9. What have the employment-level trends in your advanced reactor program areas been over the last several years?

Response:

The staffing on the advanced liquid metal reactor civilian program at the Hanford Engineering Development Laboratory (HEDL), operated for the Department of Energy by the Westinghouse Hanford Company, and at the Westinghouse Advanced Energy Systems Division (W-AESD), has declined dramatically since FY1981. Fiscal year-end staffing levels have been as follows:

	Advanced Reactor Program Staffing		
Fiscal Year	HEDL	AESD	TOTAL
1981	2278	800	3078
1982	1904	810	2714
1983	1831	720	2551
1984	1570	400	1970
1985	1310	110	1420
1986	1050	50	1100
1987*	~815	~30	~845

*Preliminary Guidance

This continuing steep decline in staffing is resulting in an irreplaceable loss of technological capability in this country, which we believe is unacceptable. In particular, at AESD, the funding and

staffing are so low that we are unable to make the kind of technological contributions that led to our leadership role in the liquid metal reactor area. We believe that liquid metal fast breeder reactors will play a vital role in meeting our long term energy needs and Westinghouse can be and should be a major participant in the program, but will not be a participant at all if present trends continue.

10. Do you think the NRC is doing enough in its safety research program or in its licensing activities to support advanced reactor licensing efforts?

Response:

As stated in my written testimony, the highest priority must be given to the restoration of the LWR and the realization of its potential to meet our energy needs. This priority extends to NRC actions in the areas of safety research and licensing reform. Licensing reform will benefit not only LWRs but advanced reactors as well.

Within the advanced reactors area (beyond LWRs), we believe it is appropriate to limit the NRC safety research until the characteristics of the next advanced reactor to be constructed are better defined. In the licensing review area, we believe NRC should continue to be funded to interact with organizations designing and developing advanced reactor concepts. The focus should be on the early resolution of generic safety issues for advanced reactors.

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May 27, 1986

The Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research and Development
United States Senate
Dirksen Senate Office Building - Room 434
Washington, D.C. 20510

Dear Senator Domenici:

I presented testimony before your Subcommittee on May 5, 1986, in the area of Policy Oversight of DOE's FY87 nuclear research and development programs. You requested my written response to a second set of follow-up questions. I am pleased to provide my response to the questions in your letter dated May 14, 1986.

Sincerely,

W. Howard Arnold

Attachment

Responses to Questions from Senate Subcommittee
on
Energy Research and Development

1. One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications, is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular R&D program.

Response

I do not agree that Strategic Defense Initiative research will have significant direct applications in the civilian reactor area. The reactor requirements for most SDI applications are expected to be significantly different from those for civilian reactors. The only current military reactor application that promises to be at least partially pertinent to the civilian program is a steady state nuclear power unit for secure power at military installations. Although the power requirement for the Multimegawatt Terrestrial Power Plant (MTP) is quite low compared to commercial reactors, our MTP could offer significant benefits to the civilian reactor area because of its synergism to the DOE ALWR program. These benefits are addressed on pages 4-5 of my prepared testimony.

The SDI research program could benefit the civilian program through the sharing of expenses of operating DOE's advanced reactor test facilities. The facilities are capable of meeting many needs of both the defense and civilian programs and the SDI programs should fund the military application testing in these facilities.

2. The development of a second generation of nuclear plant designs -- simplified licenseable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?

Response

I do not agree with this statement. Our pressurized water reactor designs have already evolved to second and third generation plants and we are continuing to add evolutionary design improvements to simplify and increase the passive safety behavior of our plants. Our designs are licensed and are operating safely in the U.S. and throughout the world.

As I discussed in my response to Question 5 in your previous set of questions, we are developing an Advanced Pressurized Water Reactor (APWR) that includes a number of design simplifications and larger design margins. We consider these to be evolutionary improvements that build upon our previous design and licensing experience. We are in the process of obtaining regulatory approval of the APWR from the NRC. I do not believe that revolutionary designs are essential to obtaining NRC approval of a standardized design concept. In fact, a revolutionary design would not have the experience base to provide the same degree of confidence in its safety as the evolutionary designs.

3. Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR and HTGR (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

Response

Since my testimony addressed both the Advanced Light Water Reactor and the Liquid Metal Reactor, I will address each of these areas in response to this question.

For the ALWR, the proposed funding is $29M in FY87. My testimony stated that we strongly supported this funding. I did not specifically request additional funding. This level of funding will not result in an NRC certified design in the foreseeable future. However, it will result in the specification of requirements for an Advanced Light Water Reactor and permit a number of attractive design characteristics to be evaluated and developed for use in future plant designs. These requirements and features will be reviewed by the NRC. These interactions with the NRC will provide valuable input to the licensing process. The overall design development and certification of an Advanced Light Water Reactor will require considerably greater resources than the current program, involving a combination of public and private sector funding.

For the LMR, we recommend a program involving extensive international collaboration to leverage U.S. expenditures and a national design of a power plant compatible with the Japanese and European programs. In establishing specific areas of collaboration, the overall guidelines should be aimed at achieving competitive economics for liquid metal reactors. Until this is accomplished and a customer base exists, it is premature to devote resources to NRC certification. Within these guidelines, collaboration should be considered in the areas of research and development, design, fabrication of components, construction, and operation of plants. Such collaboration should result in a sequential deployment of plants to develop a LMR that can be cost competitive with advanced LWRs; for example, a first plant in a foreign country such as Japan, followed by a plant in the U.S. International scopes of supply should be defined in the collaborative arrangements. Areas of particular strength that the U.S. can offer in such arrangements include liquid metal component design and analysis, component supply, and irradiation testing of fuels and materials in FFTF. The Japanese are already utilizing FFTF for fuels testing and FFTF associated facilities for blanket fabrication. We have estimated that a funding level of approximately $80 to $90 million per year would be required over the next five years to support FFTF operations and the development of a national design. Additional funding will be required to support safety testing in EBR-II. However, similar testing in the more prototypically sized FFTF will eventually be required. This program could lead to a Liquid Metal Reactor in operation in this country shortly after the turn of the century, but as stated above, consideration of NRC certification before an economical design is proven would be premature.

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37831

May 20, 1986

Mr. Pete V. Domenici, Chairman
Subcommittee on Energy Research
and Development
United States Senate
Committee on Energy and Natural
Resources
Washington, DC 20510

Dear Mr. Domenici:

This is in response to your letter of May 7, 1986, in which you enclosed questions related to the hearing of May 5, 1986.

Enclosed are answers to these questions. Please let me know if you need any further information.

Sincerely,

Fred R. Mynatt/lmm

Fred R. Mynatt
Associate Director for Nuclear
and Engineering Technologies

FRM:lmm

Enclosure

ANSWERS TO SENATOR DOMINICI'S QUESTIONS TO F. R. MYNATT

1. Question: What is your impression of the public sentiment for or against the MRS facility among the residents of and around Oak Ridge?

   Answer: I believe a majority of residents in Oak Ridge and in Roane County (where the MRS facility would be located) agree with the position set forth by the Oak Ridge/Roane County MRS Task Force. Simply stated, this position is that the facility is acceptable if the Department of Energy (DOE) will comply with certain local requirements, principally involving assurances regarding taxibility and health and safety issues. DOE officials have in general accepted these requirements.

   In contrast, at the regional and state level, it appears that a majority of East Tennessee residents and those across the state oppose the MRS. Among the reasons cited are the negative image of what they perceive to be a "nuclear waste dump"; fear of radioactive contamination in the soil, water or air; and fear of increased risk related to transportation of nuclear waste to and from the MRS site.

   The Governor and State Legislature have taken a position in opposition to an MRS facility in Tennessee. Following their exhaustive study of health, safety, and economic factors, the state's opposition focuses on the question of need for the facility and adverse socio and economic impacts rather than health and safety issues.

   I am attaching for your information some additional documents which further clarify the positions of local governing bodies.

2. Question: Aren't some of your activities in Advanced Control Test and Operation valuable in the development of military reactor power sources? Has DOE approached you with possible program proposals in the military areas?

   Answer: The Advanced Control Test Operation (ACTO) is a high fidelity reactor plant model capable of operating in real time and can be made sufficiently accurate that its dynamic behavior is essentially indistinguishable from that of a real reactor. Previous work at the Oak Ridge National Laboratory and elsewhere has demonstrated that this technique is quite feasible and is a cost-effective way of reducing design uncertainties. This important feature of ACTO, its ability to simulate a particular reactor in great detail and with extremely good fidelity, is an essential step in the development and qualification of advanced technology. This is particularly important where no prototypes or demonstration units are planned as is the case with civilian reactor development programs in the USA. In the case of military reactors, the ability to test advanced concepts with ACTO would be useful in reducing the uncertainties going into the demonstration and testing phase, and could significantly reduce the post-prototype redesign requirement. Furthermore, ACTO provides a vehicle for exploring the possible improvements in reliability that might result from varying degrees of application of automation, fault tolerant computer systems, and artificial intelligence. It would also be useful in determining the optimum allocation of functions to be performed by the operator and the control system where

complete automation is not possible or feasible. In short, we would expect ACTO to bring about the same improvement in performance in military reactors that we anticipate for civilian reactors by providing a means of testing and qualifying new technology.

There have been discussions at various levels regarding support for military activities, but no specific proposal relating to ACTO.

NUMBER 10-154-85

RESOLUTION

WHEREAS, the Nuclear Waste Policy Act of 1982 calls upon the Department of Energy (DOE) to prepare recommendations regarding the need for and location of Monitored Retrievable Storage (MRS) facilities to handle spent nuclear fuel destined for permanent repositories, and

WHEREAS, the Clinch River MRS Task Force has been jointly appointed by the Roane County Executive and the City Council of Oak Ridge to evaluate the MRS facility proposed by DOE to be constructed in the Roane County portion of Oak Ridge, and

WHEREAS, for several months the Clinch River MRS Task Force has carefully evaluated the proposal and has arrived at a position on the MRS which identifies the communities' concerns, describes the potential impacts of the proposed facility, and recommends appropriate mitigative measures, and

WHEREAS, it is the position of the Clinch River MRS Task Force that, if DOE is required by Congress to comply with those stringent but reasonable mitigative measures, the proposed MRS could be safely built and operated and would constitute a beneficial addition to the region's economic base with no harmful effects ensuing.

NOW, THEREFORE, BE IT RESOLVED BY THE MAYOR AND COUNCILMEN OF THE CITY OF OAK RIDGE, TENNESSEE:

That the City Council of Oak Ridge hereby adopts the position of the Clinch River MRS Task Force as its own and encourages the State of Tennessee, the Department of Energy, and the U.S. Congress to support the incorporation of the position into the MRS legislation and associated agreements.

BE IT FURTHER RESOLVED that with the compliance of the conditions set forth in the adopted position, the City Council of Oak Ridge would willingly accept location of the proposed MRS facility within its jurisdictional limits.

BE IT FURTHER RESOLVED that the Clinch River MRS Task Force is hereby authorized to promote with State- and Federal-appointed officials full understanding and consideration of the City's adopted position.

This the 21st day of October 1985.

APPROVED AS TO FORM
AND LEGALITY:

City Attorney

Mayor

City Clerk

#1603

OCT 16 1985

IN THE COUNTY COMMISSION FOR ROANE COUNTY, TENNESSEE

A RESOLUTION adopting the recommendations in the October 10 report of the Clinch River MRS Task Force

WHEREAS, the Clinch River MRS Task Force appointed by the Roane County Executive and the Oak Ridge City Council has submitted a report to the governing bodies requesting the adoption of a series of recommendations.

NOW, THEREFORE, BE IT RESOLVED that the Board of Commissioners of Roane County, meeting in special session on October 22, 1985, does adopt the recommendations in the October 10 report of the Clinch River MRS Task Force. Roane County thereby accepts the position that based on information to date, the MRS facility could be acceptable to Roane County and provide a net economic benefit to our citizens if conditions equivalent to those in the Task Force Report are securely satisfied by the authorizing legislation and intergovernmental agreements provided for by that legislation.

BE IT FURTHER RESOLVED that the State of Tennessee and the Tennessee Congressional Delegation are asked to help obtain adoption of the requested conditions.

BE IT FURTHER RESOLVED that the State of Tennessee and The Department of Energy are thanked for their strong cooperation with the Clinch River MRS Task Force.

Upon motion of Commissioner Langley, seconded by Commissioner Crews, the following Commissioners voted

Aye: Crews, Delaney, Dutton, Ferguson, Hatfield, Hacker, Honeycutt, Housto, Langley, Money, Renfro. (11)

The following Commissioners passed: None

The following Commissioners voted No: None

Thereupon, the County Chairman announced to the Court that said resolution had received a constitutional majority and ordered same spread of record.

APPROVED:

County Chairman

The foregoing resolution was submitted to the County Executive for his consideration this 22 day of Oct., 1985.

ATTESTED:

Dorothy M. Marshall, County Clerk

I approve/veto the foregoing resolution this 22 day of Oct., 1985.

County Executive

STATE OF TENNESSEE
COUNTY OF ROANE
Attest:
Dorothy M. Marshall

SUBMITTED BY: TEELLE FOR THE CLINCH RIVER MRS TASK FORCE

Certified a true and correct copy
October 22 19 85
Month Day Year
By: Vickie L. Short

Nice Compile
& Jot K

RESOLUTION NO. 85-19-11C

WHEREAS, THE NUCLEAR WASTE POLICY ACT OF 1982 CALLS UPON THE DEPARTMENT OF ENERGY (DOE) TO PREPARE RECOMMENDATIONS REGARDING THE NEED FOR AND LOCATION OF MONITORED RETRIEVABLE STORAGE (MRS) FACILITIES TO HANDLE SPENT NUCLEAR FUEL DESTINED FOR PREMANENT RESPOSITORIES, AND

WHEREAS, THE CLINCH RIVER MRS TASK FORCE HA^ BEEN JOINTLY APPOINTED BY THE ROANE COUNTY EXECUTIVE AND THE CITY COUNCIL OF OAK RIDGE TO EVALUATE THE MRS FACILITY PROPOSED BY DOE TO BE CONSTRUCTED IN THE ROANE COUNTY PORTION OF OAK RIDGE, AND

WHEREAS, FOR SEVERAL MONTHS THE CLINCH RIVER MRS TASK FORCE HAS CAREFULLY EVALUATED THE PROPOSAL AND HAS ARRIVED AT A POSITION ON THE MRS WHICH IDENTIFIES CONCERNS, DESCRIBES THE POTENTIAL IMPACTS OF THE PROPOSED FACILITY, AND RECOMMENDS APPROPRIATE MITIGATIVE MEASURES, AND

WHEREAS, IT IS THE POSITION OF THE CLINCH RIVER MRS TASK FORCE THAT, IF DOE IS REQUIRED BY CONGRESS TO COMPLY WITH THOSE STRINGENT BUT REASONABLE MITIGATIVE MEASURES, THE PROPOSED MRS COULD BE SAFELY BUILT AND OPERATED AND WOULD CONSTITUTE A BENEFICAL ADDITION TO THE REGION'S ECONOMIC BASE WITH NO HARMFUL EFFECTS ENSUING

NOW, THEREFORE, BE IT RESOLVED BY THE MAYOR AND ALDERMEN OF THE TOWN OF OLIVER SPRINGS, TENNESSEE:

THAT THE TOWN COUNCIL OF OLIVER SPRINGS, HEREBY ADOPTS THE POSITION OF THE CLINCH RIVER MRS TASK FORCE AS ITS OWN AND ENCOURAGES THE STATE OF TENNESSEE, THE DEPARTMENT OF ENERGY, AND THE U.S. CONGRESS TO SUPPORT THE INCORPORATION OF THE POSITION INTO THE MRS LEGISLATION AND ASSOCIATED AGREEMENTS.

BE IT FURTHER RESLOVED THAT THE CLINCH RIVER MRS TASK FORCE IS HEREBY AUTHORIZED TO PROMOTE WITH STATE-AND-FEDERAL-APPOINTED OFFICIALS FULL UNDERSTANDING AND CONSIDERATION OF THE TOWN'S ADOPTED POSITION.

THIS THE 19TH DAY OF NOVEMBER 1985.

Joseph W Wardlaw
RECORDER

Stanley E Justice Jr.
MAYOR

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37831

May 27, 1986

Mr. Pete V. Domenici, Chairman
Subcommittee on Energy Research
and Development
United States Senate
Committee on Energy and Natural
Resources
Washington, DC 20510

Dear Mr. Domenici:

This is in response to your letter of May 14, 1986, in which you enclosed questions related to the hearing of April 29, 1986.

Enclosed are answers to these questions. Please let me know if you need any further information.

Sincerely,

Fred R. Mynatt

Fred R. Mynatt
Associate Director for Nuclear
and Engineering Technologies

FRM:bdb

Enclosure

RESPONSE TO QUESTIONS FROM SENATOR DOMENICI TO F. R. MYNATT

1. Question

One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications, is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular r & d program.

Answer

While we support the Strategic Defense Initiative (SDI) we believe, along with Energy Research Advisory Board, that the military and civilian reactor development programs should be separately managed and funded. Although it seems appropriate that DOE civilian reactor test facilities should be made available to support military (SDI) applications, the military should at least pay for its share of development and testing expenses.

In general, the characteristics of reactor systems needed by the military are very different from those needed to meet civilian objectives with the exception of a dedicated military power station of a hundred megawatts or more which would, of course, also serve civilian needs. Use of advanced reactor R&D funds in military applications will benefit the civilian reactor program primarily in retaining staff and utilizing test facilities. It is not a substitute, however, and a strong civilian reactor program is needed.

2. Question

The development of a second generation of nuclear plant designs -- simplified licensable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?

Answer

Innovation is vital to the health of any technology, any industry. In 50 years the automobile has progressed from mechanical brakes, (1) to hydraulic brakes, (2) to hydraulic brakes with dual master cylinders, (3) to hydraulic disc rather than drum brakes, (4) and to electronic anti-locking brake devices which reduce the probability of skidding. Each change was a step toward improved reliability and safety. The nuclear industry must progress also - to a second generation design, a third, a fourth, etc.

We certainly do agree that the development of advanced reactor concepts featuring passive safety and standardized design is an important innovation; an important step forward in the evolution of nuclear power. In turn, we believe nuclear power is an important step forward in the evolution of electric power generation. If our future electricity supply is inadequate or excessively dependent on fossil fuels, it would have a devastating effect on our entire economy.

It appears that the preapproved standardized design concept would apply to any of the emerging designs for LWR's as well as advanced LMR or HTGR systems. The degree of modularity to be incorporated may vary somewhat from one concept to another.

3. Question

Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR and HTRG (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

Answer

Following the announcement of the Administration's reduced level of funding for these advanced reactor concepts, the NRC canceled future meetings to evaluate advanced concept designs and reassigned its personnel to other tasks. Proposed funding for the HTGR concept, for example, drops from $32 million in FY1986 to $5.3 million in FY1987. Apparently, NRC feels that the projected funding does not represent a serious effort to develop the advanced concepts and therefore does not justify continued commitment of their key staff and resources. With this situation one can only conclude that there is no timetable for NRC certification of the advanced concepts.

Assuming adequate funding, the Modular HTGR program and project schedule developed by the Gas Cooled Reactor Associates includes preliminary NRC approval of a reference plant standard design at the end of 1990 and certification of a commercial plant standard design at the end of 1997.

GA Technologies

GA Technologies Inc.
P.O. BOX 85608
SAN DIEGO, CALIFORNIA 92138
(619) 455-3000

May 14, 1986

Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U. S. Senate
Washington, DC 20510

Dear Chairman Domenici:

The attached material is respectfully submitted in response to your request of May 7, 1986. Each question has been responded to in detail and separately so they may be handled collectively or as separate individual topics.

I appreciated the opportunity to appear before your Subcommittee and to provide this supplemental information to assist your deliberations on DOE's FY'87 Nuclear Research and Development programs.

Sincerely,

R. A. Dean
Senior Vice President
Reactor Programs

Attachments

1. Could you share with us your considerable knowledge and experience relating to graphite fires? Can you shed some light on the nature of the fire at the Chernobyl nuclear plant? Are there active ways to mitigate that type of fire, or does it pretty much have to run its own course until it burns out?

Graphite Fires:

Development work on the burning of graphite has been ongoing at GA Technologies since 1969, primarily related to the processing of High Temperature Gas-cooled Reactor (HTGR) graphite fuel blocks. This development activity has included the operation of several large, highly instrumented combustors.

The testing at GA and other laboratories has shown that the self-sustained burning of large graphite structures (such as the Chernobyl reflector blocks) is very difficult. Under ideal conditions with the graphite crushed into small segments having a high surface area, and with a preheated air or oxygen supply, temperatures of 1300°F or over are required for self-sustained burning. Large graphite blocks would require higher temperatures. The maximum temperature of the graphite in the Chernobyl reactor during normal operation is reported to be less than 1400°F.

We have no information on the nature of the fire at Chernobyl other than that which is publicly available. Based on that information, our analysis indicates that the likely cause of the explosion was a hydrogen explosion resulting from a loss of coolant accident and the subsequent steam zirconium reaction. Although such an explosion could have exposed a part of the hot graphite to air, it is not clear that any significant burning of graphite would take place immediately following the explosion. As the overall temperature of the graphite increased over the period of several days due to the decay heat within the nuclear fuel, the likelihood of graphite burning would increase if a continuous supply of air was available and able to circulate up through the graphite. From what we know about the concrete structure and shields around the reactor, it would be very difficult for such a circulation pattern to be established at Chernobyl.

The burning of graphite can be mitigated by lowering the temperature of the material or by cutting off the oxygen supply. The use of sand, as reported at Chernobyl, would appear to be a most effective means to shut off the air supply. Since boronated sand was used, it would also help ensure against recriticality below the core. At the earlier Windscale uranium fire in the U.K., water was used for cooling the burning fuel elements. Very little graphite burning was experienced with that incident.

2. Will your TRIGA research related to the Multimegawatt Terrestrial Powerplant Project provide any spinoffs for your modular HTGR development work? What similarities are there between the two programs?

TRIGA and Modular HTGR

The TRIGA Power System which is being proposed by GA for the MTPP project is significantly different in technology from the Modular HTGR. They use different fuels, coolants, and power conversion systems. Also, they do not compete in the same power range. The TRIGA Power System addresses power levels of 5 to 25 MW(e), whereas the Modular HTGR is directed a power levels of 100 MW(e) and above.

The similarities between the systems is in the design philosophy which is aimed at providing simplified nuclear systems which provide the highest level of safety through passive (or inherent) system attributes, rather than through active engineered safeguards. To this extent, the engineering approaches taken on the two systems will be complementary.

3. The High Temperature Gas-Cooled Reactor (HTGR) uses a graphite core and ceramic fuel at high temperatures for energy conversion. As I understand it, it is the graphite core design that HTGR claims to have the inherent safety features. On account of the Russian nuclear accident, would you elaborate on the difference of designs and why an HTGR would be safer to operate?

HTGR Safety - Graphite and Ceramic Coated Fuel

Graphite, which is stable at high temperatures and provides a high heat storage capacity, has long been considered a means for improving reactor performance and safety. Currently, a Modular High Temperature Gas-Cooled Reactor (MHTGR) is being designed which takes advantage of these graphite properties to attain a passively safe system, i.e., the safety of the public is assured under all conditions without requiring any operator action or the operation of powered systems (such as pumps, valves, motors, etc.).

The Chernobyl nuclear disaster has raised questions regarding the design similarities and differences between the RBMK (Chernobyl type) Boiling Water Graphite Moderated Reactor, the MHTGR, and other reactor systems. In particular, the reported graphite fire has drawn attention to the MHTGR which also uses graphite as a moderator.

Studies of the Chernobyl reactor design, and of the information available on the accident, indicate that graphite was not the cause of the accident. Further, the consensus is that even if graphite had not been used as a moderator on that reactor, the accident, explosion, and release of radioactivity would still have occurred.

The Chernobyl RBMK reactor is a pressure-tube type of reactor using zirconium alloy clad uranium oxide pellets as fuel, boiling light water as the coolant, and graphite as the moderator. The fuel assemblies, which are similar to light water reactor fuel assemblies, consist of a cluster of 18 clad fuel pins located in vertical zirconium alloy process tubes through which the cooling water is circulated. The reactor is designed to perform on-line refueling. The reactor coolant inlet and outlet temperatures and pressures are essentially identical to those for U.S. boiling water reactors. The approximately 1700 process tubes which serve as the pressure boundary for the system pass through stacked graphite moderator blocks. The graphite blocks are only enclosed in a thin, stainless steel enclosure and blanketed with a helium and nitrogen mixture; they are not within the pressure boundary. The safety system incorporates an emergency core cooling system and a pressure surpression system.

The reactor is surrounded by concrete and steel shielding and support structures.

The HTGR uses ceramic coated particle fuel, helium gas as a coolant, and graphite as the moderator and the core structural material. The fuel particles consist of microspheres of uranium carbide (or uranium oxy carbide) clad with pyrolytic carbon and silicon carbide, which form a barrier and pressure vessel to retain fission products. These ceramic coatings are stable to very high temperatures. The coated particles are bonded together with a graphitic binder and inserted into large graphite fuel element blocks. The inert helium gas passes through coolant holes in the fuel element blocks. The pressure boundary for the Modular HTGR system is a steel reactor vessel which is contained in a below ground silo, and all the graphite blocks are inside the steel pressure vessel. (In the case of the Fort St. Vrain HTGR, the reactor vessel is a massive, thick-walled Prestressed Concrete Reactor Vessel.)

As indicated above, the RBMK and HTGR are significantly different types of reactors. These differences are also reflected in their susceptibility and response to accident conditions which could lead to the release from the plant of radioactivity or to a graphite fire.

Key factors in the different accident responses of the reactor system include:

Heatup Rate With Loss of Coolant

- The heatup rate of the fuel in the HTGR is very slow since the fuel and moderator are integral and the heatup rate is determined by the heat capacity of the massive graphite moderator.

- The RBMK heatup rate of the fuel and cladding is rapid since the heat capacity of the fuel assemblies is small and the fuel assemblies are thermally isolated from the graphite moderator.

Temperature Stability

- The ceramic pyrocarbon and silicon carbide fuel particle coatings (i.e., cladding) in the HTGR are stable and retain fission products to temperatures of over 3200°F. The graphite core structure gains in strength to 4500°F and is structurally sound to over 5400°F.

- The zirconium alloy fuel cladding of the RBMK loses strength and releases fission products at approximately 1300°F during a loss of coolant accident.

Chemical Interactions

- In the HTGR, the helium coolant is inert and does not react with the graphite, fuel coatings, or other system components.

- In the RBMK, an exothermic (heat producing) chemical reaction between the water coolant and the zirconium alloy fuel cladding is initiated at about 1800°F.

It is difficult to induce a self-sustaining burning of the dense, massive graphite shapes used in either the HTGR or RBMK type reactors. Studies of the graphite combustion process (supported by the DOE since 1969) have shown that even under ideal controlled conditions in which an ample supply of oxygen or air is available, graphite temperatures in excess of 1300°F are required. These conditions do not exist in normal operation of the systems and would be expected to result only as an ultimate consequence of the major accidents which could both raise the temperature of the graphite moderator and cause multiple breaches the barriers, thus permitting air contact with the graphite. (A double breach of the steel pressure vessel would be required in the MHTGR.) Further, unless a large fraction of the graphite is exposed, the amount of heat that would be generated would be small compared to the decay heat of the core.

The buildup of Wigner energy in graphite, which can lead to a rapid buildup in temperature upon release, is not a consideration in the HTGR or in the RBMK reactor, as both reactors normally operate at temperatures at which the energy is annealed out of the graphite continuously.

The accidents which would result in major releases of fission products are those which could result in a failure of the fuel cladding (or particle coatings) and the failure of the pressure boundary (pressure vessel or pressure tube). The accidents of major concern are those involving a loss or blockage of coolant for water-cooled systems or depressurization accidents for gas-cooled reactors.

In the case of the RBMK, coolant system blockages or breaks are the most likely conditions which would lead to a loss of coolant accident. The limited heat storage capacity of the RBMK fuel rods (and the thermal isolation from the graphite mass) can lead to failure of the zirconium alloy clad and the release of fission products into the system in a matter of minutes. Further damage to the cooling system and/or exothermic chemical reactions (such as the zirconium water reaction) could occur which would lead to a breach of the primary pressure boundary, to radiation release from the plant,

to an increase in graphite temperature, to possible air ingress and circulation and, if so, ultimately to graphite burning.

In addition, it also appears that the RBMK reactors are susceptible to reactivity accidents (a rapid increase in power with loss of water) which could lead to rapid steam formation and the rapid overpressurization of the system.

The loss of coolant accidents of concern for the HTGR involve the depressurization of the core, along with the loss of all active means of circulating the coolant or of removing heat from the core. Since in the HTGR the fuel particles are physically and thermally coupled with the massive core and reflector graphite, the fuel temperature increases very slowly. Further, sufficient heat is removed from the core by passive radiation and conduction to the surroundings that the Modular HTGR core temperatures never reach temperatures at which the ceramic cladding will fail or release fission products within the system.

Chemical reactions which could lead to an explosion are essentially precluded in the HTGR since the system remains blanketed with the inert helium coolant and the core components do not chemically react with each other. The introduction of water into the system could lead to the formation of hydrogen and carbon monoxide; however, this reaction is endothermic (absorbs heat) and is self-limiting.

A large sustained air-graphite reaction is also precluded since the Modular HTGR is designed to be contained within a below ground silo. This type of installation limits the quantity of air that would be available to sustain an air-graphite reaction. (In the case of Fort St. Vrain, the amount of air is limited by the massive prestressed concrete reactor vessel.)

Thus, the nature of the fuel system, coolant, and plant arrangement for the HTGR, which are dramatically different from the RBMK type system, essentially preclude the possibility of accidents such as occurred at Chernobyl and, more importantly, prevent by passive means, accident consequences which would result in significant release of radioactivity.

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May 23, 1986

Honorable Pete V. Domenici, Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
U. S. Senate
Washington, DC 20510

Dear Chairman Domenici:

The attached material is respectfully submitted in response to your request of May 14, 1986. I appreciated the opportunity to appear before your Subcommittee and to provide this supplemental information to assist in your deliberations on DOE's FY'87 nuclear activities.

Sincerely yours,

R. A. Dean
Senior Vice President
Reactor Programs

Attachments

1. One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications, is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular r & d program.

Response

The proposed Administration program calls for an overall increase in the level of those research and development programs which were initially undertaken to satisfy space and defense system requirements and for substantial reductions in those programs directed toward the civilian application of nuclear power.

Out of the planned developments and demonstrations of space and defense related systems (including the SP-100 GES, Multimegawatt Space Reactor Project, Multimegawatt Terrestrial Reactor Plant (MTR), and the Small Nuclear Power Systems Demonstration Project), it can be expected that some technologies will become available which can contribute to the civilian reactor area. To the largest extent, however, the scale, requirements, and operating environment for these defense systems are sufficiently unique that no significant applications would be anticipated for the HTGR program.

At present, the feasibility studies and proof of concept activities on the SDI program have not advanced to a point to allow for identification of those systems which will be selected for development or to define system power requirements. To date, the ground based free election lasar system appears to have requirements which would parallel those for civilian power systems. Preliminary assessments indicate that the developments to adopt power systems to meet the requirements of a lasar system will, however, focus primarily on power switching and power conditioning and would not be expected to significantly advance power reactor developments or applications.

2. The development of a second generation of nuclear plant designs -- simplified licenseable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?

Response

The development of a second generation of nuclear power plant designs that are simplified licensable designs which are inherently safer than current reactors is ideal for the successful licensing demonstration of preapproved standardized designs. Further, we believe that these passively safe designs, whose characteristics are as described in the NRC's Advanced Reactor Policy, will provide the rapid licensing that standardization promises, and thus will be highly desired by the utilities and even the public. The Modular HTGR's utility user organization, Gas-Cooled Reactor Associates, several years ago formulated requirements detailing stringent criteria that dictate passive safety characteristics that are easily demonstrated to both the regulator and the public. Public concerns have certainly been heightened by the Chernobyl accident and a new approach to safety design is surely called for.

3. Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR and HTGR (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

Response

The projected schedule for NRC's certification of the Modular HTGR is shown on the attachment. This schedule was included in the HTGR Licensing Plan submitted by DOE earlier this year to NRC and anticipates NRC'S Final Design Approval in 1995 followed Final Rule Making in 1997.

Sufficient funding is being provided by DOE to support completion of the Preliminary Safety Information Document (PSID) by the end of FY'86 which is critical to the subsequent schedule. Approximately the same level of funding ($28M) is required in FY'87 to progress the design and continue interactions with NRC. In subsequent outyears the design, licensing and supporting technology funding peaks at approximately $60 million (unescalated) about 1991, to meet the proposed schedule. This level of funding does not include support for a demonstration project which is expected to be jointly funded by the industry and government.

Attachment to response to
Question 3.

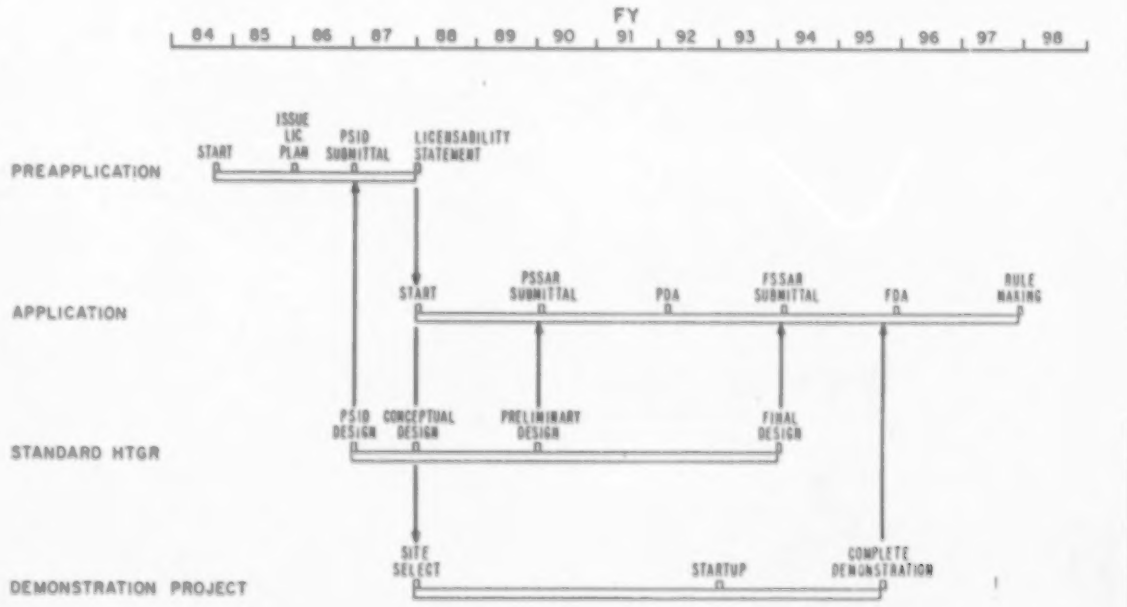

FIGURE 1-1
SCHEDULE FOR HTGR LICENSING ACTIVITIES

COMBUSTION ENGINEERING

May 27, 1986

Senator P. V. Domenici, Chairman
Subcommittee on Energy Research
and Development
United States Senate
Washington, D.C. 20510

Subject: Responses to Questions Regarding Federal Nuclear Research Programs

Dear Senator Domenici:

In response to your May 14 letter, it is a pleasure to provide the attached answers to your questions regarding civilian reactor applicability of SDI research, development of second generation nuclear plant designs, and estimated timetables for NRC certification of the ALWR, LMR, and HTGR.

Please let me know if I can be of further assistance in these matters.

Sincerely yours,

Warren P. Chernock

Warren P. Chernock
Vice President
Advanced Nuclear Systems

WPC:mk

Attach.

Power Systems
Combustion Engineering, Inc.
1000 Prospect Hill Road
Post Office Box 500
Windsor, Connecticut 06095-0500
(203) 688-1911
Telex: 99297

Responses to Questions Regarding

Federal Nuclear Research Programs

Question 1: One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications is that the Strategic Defense Initiative will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular R&D program.

Answer: No, I do not agree with the Administration's argument on this matter. Although there will undoubtedly be significant areas of SDI developments which are later adopted for civilian purposes, I am not aware of any facet of the SDI program whose ultimate objective either is a commercially viable nuclear energy source for civilian applications or which could reasonably and economically be used for that purpose.

The military emphasis is on operation at a relatively modest housekeeping power level with occasional rapid increases to very high power levels for periods on the order of one hour. The applications also place great emphasis on security from both saboteurs and direct enemy attack as well as on installation in remote high altitude locations, whereas considerations necessary for civilian success, such as low capital and power generation costs, are low in priority.

This is not to say that a successful large-scale advanced military reactor program might not provide an excellent foundation of technical expertise and industrial capability for civilian power generation at some future time. The civilian spin-offs from the Naval nuclear propulsion program of the 1950's have certainly been very important to the development of commercial nuclear power. However, since we think it unlikely that such a complex power generation method will be chosen as the optimum solution for the SDI application (given the current availability of far less complex solutions), we believe that it would be unwise to depend upon SDI projects to produce significant benefits for civilian nuclear power generation.

Therefore, while the SDI program will probably produce noteworthy advances in instrumentation and other high technology areas related to nuclear power development, it is not obvious that this program will support the task of advanced design and demonstration plant construction for a practical civilian power plant; and it is in these areas that Federal support is crucial to the future of nuclear energy.

Question 2: The development of a second generation of nuclear plant designs -- simplified licensable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates a pre-approved standardized design concept. Do you agree with this statement? Why or why not?

Answer: No, I do not agree with this statement. I believe that the credibility of the concept of pre-approved licensing of standardized designs is entirely dependent on the extent to which such standardized designs can be demonstrated to be firmly based on technology which is in place and functioning today. That is, the standardized design must achieve its cost and safety superiority through the incorporation of the best features, designs, and operating experience from today's light water reactor power plants (both BWR and PWR).

Question 3: Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR, and HTGR (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

Answer: With respect to the Advanced Light Water Reactor (ALWR), the DOE and the industry are currently working to a schedule which calls for NRC certification in 1989, and achieving this schedule will require the virtual continual participation of the NRC in the ALWR program. However, while we understand that the funding levels recommended for this purpose would be able to support this certification schedule, we do not know to what degree the NRC's ability to maintain this schedule would be adversely affected by a reduction in funding to the levels called for in the Administration's budget.

As for the Liquid Metal Reactor (LMR) and High Temperature Gas Cooled Reactor (HTGR) certification programs, both the HTGR and the Sodium Advanced Fast Reactor (SAFR) version of the LMR are being developed on schedules calling for certification in the 1997-1998 time frame; and both programs are based on a process of continuing interaction with the NRC, including timely submittal and review of various documents.

Of most immediate concern are the plans in both programs for submittal of Preliminary Safety Identification Documents during FY 87. It is crucial to both programs that the NRC review these documents and issue licensability statements during FY87. The importance of obtaining these NRC licensability statements at this stage is that certain inherent passive safety characteristics are a basic criterion for both of these designs; and, until the NRC has established its position on the acceptability of the provisions included in these designs, all other claims regarding these programs (e.g., cost and schedule) will remain somewhat speculative.

GAS-COOLED REACTOR ASSOCIATES
10240 Sorrento Valley Rd. Ste. 300
San Diego, CA 92121-1605
(619) 455-9500

Chairman

May 16, 1986

The Honorable Pete V. Domenici
Dirksen Senate Office Building
Room SD-434
Washington, D.C. 20510

Dear Senator Domenici:

Enclosed are our responses to the Subcommittee's questions that were submitted on May 7, 1986.

If there are any further questions or need for additional information, please contact me or Dan Mears, General Manager of GCRA.

Sincerely,

R. F. Walker

R. F. Walker, President
Public Service Company
of Colorado and Chairman,
GCRA Board of Directors

Enclosure

FOLLOW-UP QUESTIONS FOR R. F. WALKER (GCRA)
FROM SENATOR PETE V. DOMENICI

HEARING BEFORE THE SENATE SUBCOMMITTEE ON ENERGY R&D - 5/5/86

Question #1

How long has the Public Service of Colorado operated Fort St. Vrain HTGR plant? What is your experience with respect to the radiation levels within the primary system of the facility?

Answer

Fort St. Vrain began generating electricity on December 11, 1976.

Radiation levels within the primary system have been very low, with circulating activity a factor at 60 below the design value. As a result, personnel exposure has typically totalled about 1 man-rem per year, in comparison to an average exposure at commercial nuclear plants exceeding 500 man-rem per year.

Question #2

What was the Department's FY86 funding level for HTGR research?

In the Joint Participants' statement, the request of $32 million is made. What is the utilities' contribution towards cost-sharing with the $32 million request of the Department?

Answer

While the Congress appropriated $32 million for HTGR development in FY 1986, the Department has released, to date, $27 million. Most of the balance has been used for "taxes" to fund special studies within DOE and other projects.

Utility funding for the HTGR Program in 1986 will be approximately $4 million. As part of the Demonstration Project initiative, the target for utility funding in 1987 is $8 million. A key element to establishing the Project initiative and the targeted utility commitment is a stable Government program and support for the Project initiative.

Question #3

A demonstration project is estimated to cost $885 million and to be commercial by the turn of the century. What would be the federal government's contribution? The utilities' share?

Answer

The cost sharing arrangements for the Demonstration Project have not been officially adopted by the prospective project participants. However, the proposed model under development by GCRA results in the following percentage splits on the total Project cost and related technology development.

Utilities	42%	
Vendors	10%	
Government	48%	(36% Project & 12% Technology)
	100%	

Question #4

Could you explain to the Committee the difference between the technology and safety systems at Fort St. Vrain and that at the Chernobyl plant?

Answer

Although the Russian Chernobyl plant and Fort St. Vrain are similar in that they both use graphite for moderating neutrons, there are fundamental differences in other aspects of the technology which profoundly affect the risks from potential accidents. These differences primarily center on differences in the type of fuel, coolant and means of inerting the graphite used in the two reactors.

The fuel used in the Chernobyl reactor is clad in zirconium metal and cooled by light water. In the event of a loss of coolant, the heatup rate of the fuel and cladding is rapid since the heat capacity of the fuel assemblies is small and the fuel assemblies, once the water coolant is lost, are effectively thermally isolated from the graphite moderator. Thus, in the event of a loss of coolant accident, the fuel and cladding can overheat leading to a fission product release in a matter of minutes to hours. Furthermore, if the zirconium cladding should overheat, an exothermic (heat producing) reaction between the water coolant and the zirconium cladding can occur producing hydrogen gas. The production of hydrogen by this fuel-coolant interaction has been identified as the most likely cause of the explosion and subsequent fire which took place at Chernobyl. Finally, at the Chernobyl plant, the graphite is surrounded by a "reactor space", a low-pressure boundary filled with helium and nitrogen. This system does not constitute a pressure vessel and hence may have been fairly readily failed by the overpressure condition which could occur if the tubes which normally contained the water coolant were melted allowing steam to enter the space.

By comparison, at Fort St. Vrain, the fuel cladding is ceramic pyrocarbon and silicon carbide. This ceramic material is capable of retaining fission products at much higher temperatures than metallic materials. In addition the heatup rate of the fuel in the HTGR is very slow and independent of the helium coolant since the fuel and moderator are integral and the heatup rate is determined by the heat capacity of the massive graphite moderator. In the HTGR, the helium coolant is inert and does not react with the graphite or fuel coatings. Thus even if the graphite or fuel do heat up, there is no possibility of producing hydrogen from a fuel-coolant interaction such as occurred at Chernobyl. Finally, at Fort St. Vrain, the reactor graphite is surrounded by a massive, thick-walled Pre-stressed Concrete Reactor Vessel (PCRV) which is designed to withstand very high internal pressures. Major penetrations into this vessel are sealed, in each case, by two independent closures. In effect, this PCRV provides the equivalent margin of protection of a containment building.

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Question #5

When you state that your primary goal in FY 87 is to obtain a licensability statement from the NRC, what exactly do you mean in terms of the DOE program content? What exactly does an NRC "licensability statement" entail?

Answer

The primary goal of the MHTGR program in FY87 is to obtain a licensability statement from the NRC. To obtain this statement, the DOE program is producing for NRC review three major documents:

1) A Preliminary Safety Information Document (PSID) which will be similar in format and content (although in less detail, owing to the conceptual stage of the design) to a PSAR which is normally filed with the NRC to obtain a Construction Permit. The PSID will describe the design, its design bases, and provide an analysis of the consequences of bounding accident events.

2) A Probabilistic Risk Assessment (PRA) which provide an analysis of the risks of accident events, even events which are considered so improbable as to not be considered in the normal design basis for the plant design.

3) A Technology Plan which will describe the proposed development plan for the concept which will verify the analytical tools and data used in the safety analysis.

These three major documents are scheduled to be submitted to the NRC by the end of FY86. The NRC has then been requested to review these documents and produce a Preliminary Safety Evaluation Report. After meetings with the Advisory Committee on Reactor Safeguards (ACRS), which would describe the results of the NRC staff review and receive comments from the ACRS, it has been further requested that the NRC issue a letter which identifies their findings with regard to the adequacy of the reactor design, the design bases and requirements to be used in further design efforts and the adequacy of the technology program. This letter, which is being referred to as a licensability statement, if positive, would provide the basis of confidence for all parties to commit resources to more detailed design of a demonstration plant and ultimately to their commitment to manufacturing and construction.

Question #6

Is NRC doing enough in its safety research or its licensing areas to support the licensing of advanced reactors such as the modular HTGR?

Answer

A near term program of needed interactions with the NRC on the MHTGR has been identified by the DOE program in a document known as the Licensing Plan for the Standard HTGR (HTGR-85-001). The NRC reviewed this plan and in a letter of July 1985 committed NRC resources to the accomplishment of the activities identified in the plan. In parallel, the NRC has also drafted an Advanced Reactor Licensing Policy which clearly advocates and supports early NRC interaction in reviewing designs such as the MHTGR. Consistent with this, a number of meetings have been held in FY85 and FY86 between the HTGR program and the NRC staff and the ACRS to familiarize each with the technology and to discuss approaches to developing licensing bases and requirements unique to the MHTGR. In February of 1986, however, the NRC issued a letter which retracted their former support to the review of advanced reactor concepts to the schedule identified in the DOE plans. This retraction, the letter states, owes to a reduction in NRC manpower and technical support budgets allocated to advanced reactors necessitated by the Gramm-Rudmann-Hollings act. Accordingly, since February, there have been no further interactions with the NRC staff on the MHTGR. Work, however, is continuing on schedule under the DOE program to produce the licensing review documents as originally scheduled. We consider it essential to the further progress of work on the MHTGR to reinstate the relatively modest resources orginally committed by the NRC to continue interactions against the schedule of the licensing plan.

GAS-COOLED REACTOR ASSOCIATES
10240 Sorrento Valley Rd, Ste. 300
San Diego, CA 92121-1606
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Chairman

May 27, 1986

The Honorable Pete V. Domenici
Senate Appropriations Subcommittee
on Energy and Water Development
Dirksen Senate Office Building
Room SD-434
Washington, D.C. 20510

Dear Senator Domenici:

Enclosed are our responses to the Subcommittee's questions that were submitted on May 14, 1986.

If there are any further questions or need for additional information, please contact me or Dan Mears, General Manager of GCRA.

Sincerely,

R. F. Walker

R. F. Walker, President
Public Service Company
of Colorado and Chairman,
GCRA Board of Directors

Enclosure

FOLLOW-UP QUESTIONS FOR R. F. WALKER (GCRA)
FROM SENATOR PETE V. DOMENICI

HEARING BEFORE THE SENATE SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
4/29/86

Question #1

One of the arguments used by the Administration to support reduced funding for civilian nuclear research in favor of research on military (Strategic Defense Initiative) applications, is that the Strategic Defense Initiative research will also have significant applications in the civilian reactor area. Do you agree with this argument? Why or why not? If there are areas of research with civilian applications, please describe generally and provide an assessment of how significant these research areas are to your particular R&D program.

Answer

In principle, any non-civilian application of advanced nuclear technology will have technology transfer benefits to civilian applications. While the potential civilian benefits from SDI applications of advanced nuclear power systems are obvious, they are viewed as premature bases for reducing civilian reactor development programs.

There are no known areas of specific SDI "research" that are applicable to the HTGR program. However, there are broad considerations of power needs within the SDI program for which some could be met by an HTGR. However, the SDI requirements, plans and commitments are viewed as too speculative at this time to warrant funding reductions in any of the civilian reactor development program.

Question #2

The development of a second generation of nuclear plant designs -- simplified licensable designs which are inherently safer than current reactors -- would appear to be essential to the success of an NRC licensing regime which incorporates the preapproved standardized design concept. Do you agree with this statement? Why or why not?

The development success of an inherently safe, second generation nuclear power system, such as the Modular HTGR, is based on achieving the elusive preapproved standardized design concept. However, to say that a second generation nuclear plant is "essential" for this concept appears too strong. It's a matter of relative difficulty and cost.

Question #3

Assuming the Administration's requested level of funding for civilian reactor research, what is your estimate of the timetable for NRC certification of the ALWR, LMR and HTGR (individual panelists should respond regarding reactor with which they are most familiar)? What would the timetable be assuming the levels of funding requested in your testimony?

Answer

With the Administration's requested level of funding for the HTGR, the estimated timetable for the NRC's design verification is probably never! The funding request for the HTGR made through the Joint Participants' Statement is based on a Demonstration Project by the mid-1990s that will provide invaluable support for the design verification of the Modular HTGR by the turn of the century.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1987

(Energy Research and Environment, Safety and Health)

MONDAY, JUNE 23, 1986

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2 p.m., in room SD-366, Dirksen Senate Office Building, Hon. Daniel J. Evans, presiding.

Present: Senators Evans, Domenici, Warner, Hecht, and Ford.

Also present: Marilyn Meigs, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. DANIEL J. EVANS, A U.S. SENATOR FROM THE STATE OF WASHINGTON

Senator EVANS. This hearing of the Senate Subcommittee on Energy Research and Development, will please come to order.

This hearing is on the Department of Energy fiscal year 1987 budget authority for the Office of Energy Research and Office of Environment, Safety and Health.

Senator Domenici is expected sometime soon. However, if the Department of Energy Research would inform us as to how we could better, and more quickly, get the Eastern shuttle to fly on time, he would have been here before this.

With that, the first panel is Mary Walker, assistant secretary for Environment, Safety and Health, and Dr. Trivelpiece, director of the Office of Energy Research of the Department of Energy.

I would ask Ms. Walker to go first, so that we can deal with the subjects that she has under her responsibility, and then Dr. Trivelpiece will go next.

That leads into the second panel, and the subject on which we will spend the rest of the afternoon.

With that, Senator Ford, do you have any initial comments?

Senator FORD. If you are talking about airlines, when I came in, they own the rain and fog. They can cancel and delay anything.

Senator EVANS. How well do I know.

Ms. Walker, you may proceed.

STATEMENT OF MARY L. WALKER, ASSISTANT SECRETARY, ENVIRONMENT, SAFETY AND HEALTH, DEPARTMENT OF ENERGY, ACCOMPANIED BY GEOFFREY JUDGE, ACTING DIRECTOR, OFFICE OF BUDGET AND ADMINISTRATION, ENVIRONMENT, SAFETY AND HEALTH, DEPARTMENT OF ENERGY

Ms. WALKER. Thank you, Mr. Chairman.

I appreciate the opportunity to discuss with you today, the Department's budget request for fiscal year 1987 for Environment, Safety and Health.

Last September as part of the continuing commitment to this area, Secretary Herrington announced a series of initiatives, to strengthen environment, safety and health functions within the Department of Energy. I would like to take this opportunity to bring you up to date on what has been accomplished through the initiatives thus far.

The first of the Secretary's initiative was to centralize and strengthen the function at headquarters under a newly created Assistant Secretary position. This has been accomplished.

The second initiative is the technical safety appraisal, of our major nuclear facilities. This was begun last February.

The first initiative is the environmental survey of all DOE sites, the first on-the-ground work began last week, although planning has been continuing many months previous to that.

Lastly, the Secretary indicated these would be a computer-assisted tracking system, to utilize the information made available through these appraisals, and studies on a continuing basis to monitor our compliance and oversight. This is currently in the planning stages.

DOE operates large and complex research, and production facilities across the country. Many of these facilities are 30 years old or more. While the safety record of our nuclear facilities has been extraordinarily good, safety technology continues to evolve and we want to be sure that we are using the best operating techniques.

We also want to continue to look critically at ourselves to assure continuing improvement. The technical safety appraisal will look at, how well current operations comply with all current regulations, procedures and policies and will consider new measures that can be adopted to increase further the margin of safety. In other words, we will be seeking to reduce any risk to acceptable or safe levels.

Field work has been completed for the first four technical safety appraisals, and planning is well underway for additional appraisals in this fiscal year.

We have already completed the technical safety appraisals for the "N" reactor at Hanford, WA, and in July will undertake the appraisal of the four reactors at the Savannah River site in South Carolina.

At the Secretary's direction, we have accelerated the schedule for review of these sites, in light of the accident at Chernobyl power plant.

In addition, the Secretary has requested special reviews be made of the "N" reactor because it is the only one of our major production reactors that utilizes the graphite moderating system. It will

take 2½ years or until the end of 1988 to complete all of the technical safety appraisals.

On the environmental side, as you know, environmental contamination problems left by the past, and sometimes more current operations, have been found in several of our sites. The purpose of the environmental survey is to look at all our sites and catalog existing environmental problems so that we can set priorities for corrective action.

Budget constraints, and the wide expenditure of funds, make it crucial that we set realistic priorities in this area. The first environmental survey was begun last week, at the Feed Materials Production Center at Fernald, OH. We expect to take 2½ years to complete all the surveys of our facilities. The surveys will form the basis of an ongoing environmental audit program that will begin at its end.

In January 1986 the Secretary also signed an environmental policy statement for the Department, the first effort, as far as I know, for the head of this agency. Pursuant to this policy, we have developed and implemented an environmental issue coordination process to assure that the Department's operations are uniformly conducted in an environmentally sound manner and in combination with the letter and in a spirit applicable to statutes, regulations and standards.

Several significant compliance issues have been successfully resolved under this coordination process.

Lastly, planning for the computer-assisted tracking system has been ongoing for some time. It is being designed by the people in my office who will actually be using the system to track compliance. We hope this system will be operational by early fiscal year 1987 and further development and fine tuning will be accomplished in fiscal year 1987.

The 1987 budget request for Environment, Safety, and Health is $76.1 million, a $29.2 million increase over the fiscal year 1986 level. This increase is principally for the work on the environmental surveys and principally for the sampling and analysis portion of it.

We are proposing to fund that at $30 million in fiscal year 1987. We believe these will be dollars well spent. They will enable us in the future to make sure that necessary expenditures are well planned and cost effective.

I will be happy to answer any questions you might have.

[The prepared statement of Ms. Walker follows:]

STATEMENT OF

MARY L. WALKER

ASSISTANT SECRETARY FOR
ENVIRONMENT, SAFETY AND HEALTH

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH
AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

June 23, 1986

Mr. Chairman and Members of the Subcommittee, I am pleased to be here today to discuss with you the Department's budget request for FY 1987 for the Environment, Safety and Health Program.

NATIONAL ENERGY POLICY PLAN AND SAFE, ENVIRONMENTALLY SOUND OPERATION OF DOE ACTIVITIES

The overall goal of our national energy policy is to foster an adequate supply of energy at reasonable costs. The two strategies to achieve this goal are (1) to maximize the practical reliance on the free decisions of the entire populace, while maintaining public health and safety and environmental quality, and (2) to promote a balanced and mixed energy resource system. In addition, the Department is responsible for the manufacturing of nuclear weapons for national defense purposes. It is the stated policy of the Secretary of Energy to conduct all of the Department's operations in an environmentally safe and sound manner. Protection of the environment and the public is of paramount concern and importance to the Secretary and the Department.

GOAL OF OFFICE OF ENVIRONMENT, SAFETY AND HEALTH

The goal of the Environment, Safety and Health (ES&H) Program is to:

- o assure conformance of the Department's activities with all applicable environmental laws and regulations and assure that the health and safety of workers and the public are protected;

- o assure that national environmental protection goals are incorporated into the formulation and implementation of energy policy and programs;

- o assure that environmental, safety and quality assurance concerns are identified, prioritized and addressed through corrective and remedial actions, and areas of environmental and safety risk are reduced to levels as low as practical;

- o develop policy options for the Department on the effects of national environmental policy and regulations on U.S. energy industries and energy supply and demand; and

- o provide liaison with other federal agencies, such as the Environmental Protection Agency, concerning regulatory efforts and specific actions of those agencies that may have an impact on DOE operations.

PRINCIPAL STATUTORY AUTHORITY

As its principal basis in law, the Environment, Safety and Health program responds directly to 19 statutory requirements which are listed and briefly summarized in our FY 1987 budget submission.

ENVIRONMENT, SAFETY AND HEALTH RECORD

Among the primary objectives of the ES&H program are the assurance of the safety and health of the public and the quality of the environment, the protection of Government properties against

accidental loss and damage, and the assurance of safe and healthful work places and conditions of employment for both DOE and contractor employees at approximately 225 industrial and research sites across the United States involving both nuclear and non-nuclear operations.

The priority the Department places on its safety and health program is demonstrated by the positive results realized from that program and by the Department's excellent safety record.

Without exception, for each year since its creation, the Department has carried out its operational missions with a safety and health record that is at least two-to-three times better with respect to fatalities, injuries, and illnesses, and more than ten times better with respect to property protection, than that of the private sector.

The increasingly complex and dynamic situation regarding environmental laws and regulations has required us to reevaluate our environmental programs. Some of our facilities have been in use for nearly 40 years and many of the environmental problems we are finding at DOE facilities represent a "legacy of the past," from activities conducted in a different atmosphere and under different standards than are applied for today's more sophisticated and highly publicized environmental and safety criteria. What was acceptable in 1945 is not acceptable in 1986.

NEW INITIATIVES IN ENVIRONMENT, SAFETY AND HEALTH

On September 18, 1985, Secretary Herrington announced a series of initiatives to strengthen the environment, safety and health function within the Department of Energy. These new initiatives are the result of a thorough review of the Department's environment, safety and health function by ES&H and senior management of the Department. I would like to highlight these initiatives for you and report on some of the progress we have made in implementing them.

- First, oversight responsibility for the environment, safety and health function in the Department has been consolidated and upgraded under the new Assistant Secretary for Environment, Safety and Health. ES&H is now integrally involved in the operation of the Department at all levels, is directly overseeing the environmental and safety aspects of the Department's ongoing operations and necessary corrective actions, and is more integrally involved in decisions affecting those operations.

- Second, ES&H will conduct a baseline Environmental Survey of all DOE facilities to identify Department-wide existing environmental problems and areas of potential risk and to prioritize corrective action. The onsite Survey activities, begun last week, will take about 2 1/2 years to complete and will enable the Department to develop long-

range planning for correcting environmental problems and reducing potential risks.

- Third, ES&H will conduct Technical Safety Appraisals of DOE's nuclear facilities to determine compliance with safety requirements, industry lessons learned, and licensed facility requirements. The Technical Safety Appraisals will review all aspects of safety, including organization and administration, operations, maintenance, training and certification auxilary systems, emergency readiness, technical support, security/safety interface, experimental activities, facility safety review, nuclear criticality safety, radiological protection, personnel protection, and fire protection. The Technical Safety Appraisals, begun in February 1986, will also be completed in about 2 1/2 years.

In addition, other elements of the new initiatives or our increased role include: (1) revising the environment, safety, and health orders in the Department to strengthen ES&H's oversight role and responsibilities with respect to DOE operations; (2) increasing guidance activities and enhancing liaison with State and Federal agencies; (3) taking a more aggressive ES&H role in the development and implementation of environmental and safety policy for the Department; (4) developing an improved field reporting and computer assisted tracking system; and (5) enhancing the professional development of ES&H staff.

The new initiatives and these additional steps, represent the Secretary's personal commitment to a quality environment and to the safety and health of our workers and all Americans. The initiatives assure that the Department has solid information upon which to base its clean-up and corrective actions, and strong oversight to ensure continued safe and environmentally sound operations.

I would like to emphasize that none of the new ES&H efforts described above is meant in any way to suggest that line management in the Department has a decreased responsibility for safety and environmental matters. Line management has the basic responsibility to conduct its activities in accordance with the Secretary's environment, safety, health and quality assurance policies. The fact that ES&H has been strengthened does not alter this. Rather, these changes will provide line management with greater technical assistance, more consistent policy, and the Department with more credible oversight and validated success in these areas.

PROGRAM ORGANIZATION

The new Environment, Safety and Health Program consists of six major units: Nuclear Safety, Operational Safety, Quality Assurance, Environmental Audit and Compliance, Environmental Guidance, and Environmental Analysis. Their activities include: the development of policies and standards; oversight, including the Environmental Survey, Technical Safety Appraisals and func-

tional appraisals to monitor program and field performance in complying with DOE safety policies and standards, and in achieving effective safety and quality performance; environmental issues coordination; technical assistance as needed to foster compliance; maintenance of the resources to respond to radiological emergencies; the review of National Environmental Policy Act documents; and the analysis of energy/environmental issues pertaining to the energy supply industry and to energy use arising from environmental legislative and regulatory activities.

FY 1986 PROGRAM PLANS

During FY 1986, we are focusing our activities on implementing the Secretary's new initiatives and upgrading our base program from within existing Departmental resources. I am pleased to report that significant progress has been made during this fiscal year.

- The reorganization of the headquarters ES&H function is essentially complete, and, I believe, the new ES&H office is becoming integrally involved in the operations of the Department at all levels.

- Field work has been completed for the first four Technical Safety Appraisals, and planning is well underway for four additional Technical Safety Appraisals this fiscal year. Included in the second group is N-Reactor in Hanford, Washington and four reactors at the Savannah River site in Aiken, South

Carolina. At the Secretary's direction, we have accelerated the schedules for the review of these two sites as part of our commitment to conduct a special review in light of the accident at the Chernobyl power plant. In addition, the Secretary has requested that several special reviews be made of N-Reactor because it is the only one of the five that utilizes a graphite moderating system.

- We completed planning and preparatory activities for the Environmental Survey and last week began the baseline at the Feed Materials Production Center in Fernald, Ohio. The Fernald survey is being conducted by a team of experts under the direction of a DOE team leader and assistant team leader. It covers all areas of environmental concern including air pollution, water pollution, soil contamination and hazardous waste management. The survey team will observe operations, review records and documents, interview plant personnel and study environmental conditions at the site. Current plans call for 4 other sites to be initiated by the Environmental Survey in FY 1986. These 4 sites are the Mound Plant in Ohio, the Portsmouth Gaseous Diffusion Plant in Ohio, the Rocky Flats Plant in Colorado, and the Hanford Reservation in the State of Washington.

- As part of the Secretary's January 1986 Environmental Policy Statement, we have developed and implemented the DOE Environ-

mental Issue Coordination Process to assure that the Department's operations are consistently conducted in safe and environmentally sound manner and in compliance with the letter and spirit of applicable environmental statutes, regulations, and standards. Several significant compliance issues have been successfully resolved under the Coordination Process by applying the goals, objectives, and commitments embodied in the Policy Statement. For example, we established a DOE Interim Policy on State Regulation of Radioactive Mixed Waste that encourages DOE, EPA and state cooperation to promote positive relationships with states that are hosts to the Department's operations. The Interim Policy provided the framework that is leading to the successful resolution of a serious issue concerning state regulation of hazardous and radioactive mixed waste at DOE's Rocky Flats Plant in Colorado. More specifically, earlier this month DOE signed, with the State of Colorado and EPA, an agreement in principle that will lead to a final agreement for compliance we plan to have signed by June 30, 1986. The agreement will provide for state participation in the regulation of radioactive mixed waste and enable DOE to move forward to correct past problems related to waste disposal.

- We have also been providing expert technical advice, guidance and assistance to DOE field offices in the development of programs and projects undertaken in response to environmental compliance requirements including primarily those under the

Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

- We are currently developing a system for independent verification of DOE contractor reported environmental monitoring data and plan to implement the system by early 1988.

- The DOE Safety and Quality Assurance Orders have been revised and are undergoing final Departmental review. The revised orders will be issued very soon.

- We are conducting reviews of reactor safety analysis reports and nuclear facility safety analysis reports. These are in-depth multidisciplinary reviews to assure that an adequate degree of protection of the safety, health, and environment has been designed into reactors, high hazard nuclear facilities, and selected moderate hazard nuclear facilities.

- We are participating in analyses related to regional and global environmental issues such as acid rain, climate change, deforestation, and nuclear winter as well as analysis of regulatory and legislative proposals affecting energy elements. Much of this work involves participation in interagency and international meetings.

FY 1987 FUNDING

The FY 1987 budget request for the Environment, Safety and Health Program is $76.1 million, an increase of $29.2 million above the adjusted appropriation for FY 1986 as noted in the following table. The increase is principally for beginning work on the Environmental Survey. The Environmental Survey is supplementary to the base program for environment, safety and health, and to ongoing environmental projects and corrective actions. Thus, funding for the Environmental Survey will not displace these other efforts.

FUNDING SUMMARY

(Budget Authority in Millions)

Environment, Safety and Health	FY 1986 Adjusted Appropriation	FY 1987 Request	Change
Environmental Audit and Compliance	$ 7.5	$ 34.0	$ +26.5
Nuclear Safety	16.9	17.2	+ 0.3
Operational Safety, Quality Assurance, and Environmental Guidance & Analysis ..	11.4	11.3	- 0.1
Program Direction	9.7	11.5	+ 1.8
Capital Equipment	1.4	2.1	+ 0.7
Total ES&H	$ 46.9	$ 76.1	$+29.2
Staffing (FTE's)	125 a/	127 a/	+2

a/Excludes 3 FTE's budgeted under the Nuclear Waste Fund.

FY 1987 PROGRAM PLANS

Environmental Audit and Compliance. This new office has the responsibility for conducting the Environmental Survey, for coordinating the Department's environmental issues review, for field liaison on compliance issues and agreements, and for continued environmental audits after the Survey. The FY 1987 budget request is $34.0 million, an increase of $26.5 million. During FY 1987, we will conduct the Survey for approximately 20 DOE sites including sampling and analysis, and continue to coordinate Departmental environmental activities such as compliance with RCRA and CERCLA requirements.

Nuclear Safety, $17.2 million, has been increased 2 percent over FY 1986, with significant activity occurring on the new Secretarial initiative, the Technical Safety Appraisals. During 1987, we will perform extensive safety reviews of DOE facilities, including twenty-three Technical Safety Appraisals of Category A reactors and high hazard nonreactor nuclear facilities.

Emphasis will also be placed on the review and concurrence of reactor and nonreactor nuclear facility safety analysis reports covering new facilities or modifications and upgrading of existing facilities. The program will also maintain a viable radiological emergency response capability for DOE facilities utilizing the Atmospheric Release Advisory Capability and the Aerial Measurement System. Emergency response support will be made available to the Department of Defense, and in coordina-

tion with the Federal Emergency Management Agency, on request to other federal and state authorities.

The budget request for Operational Safety, Quality Assurance, and Environmental Guidance and Analysis is $11.3 million which is essentially the same amount in FY 1987 as appropriated in FY 1986. Emphasis will be placed on issuing revised environmental protection, safety and health protection policy guidance for Departmental projects and operations, including comprehensive direction on hazardous waste (RCRA/CERCLA) requirements. This includes an aggressive role in developing and coordinating comments on new and revised environmental statutes, rules and policies of other agencies potentially impacting DOE and assuring clear, adequate guidance to our field operations. The base activities of appraising operational safety of the DOE facilities, assisting DOE program and field organizations in their development and implementation of the Quality Improvement Program concept, independently reviewing NEPA and other supporting environmental documents to assure adequate compliance, and participating in Departmental environmental analysis including acid rain issues will continue.

The budget request for Program Direction, $11.5 million, represents an 18 percent increase in FY 1987 over FY 1986 to support the increased staff necessary to implement the new Secretarial initiatives of the Environmental Survey and the Technical Safety

Appraisals, and associated increased travel and contractual support.

The budget request for Capital Equipment, $2.1 million, is $0.7 million greater in FY 1987 than FY 1986. The increase is principally required to establish and operate the Computer Assisted Tracking System for environmental and safety data to monitor compliance and progress in completion of corrective actions at DOE facilities, and to assist ES&H in the early identification and correction of adverse safety trends and in reducing areas of environmental and safety risk.

SUMMARY

In summary, Mr. Chairman, the Secretary's new initiatives in environment, safety and health underscore the Department's commitment to protecting the environment and giving high priority to public and worker health and safety in our operations. We have made significant progress in FY 1986 towards improving environment, safety and health at Department of Energy facilities. Our FY 1987 budget request will enable us to continue to accomplish our environment, safety and health goals in a responsible manner.

Senator EVANS. Thank you very much.

Let me start with one of the fundamentals in your statement of the overall goal. The Secretary's strategy is to promote a balanced and mixed energy resource system.

Would you care to be more explicit on what, in your opinion or your view, is the Department of Energy's description of a balanced and mixed energy resource system?

Ms. WALKER. Perhaps I could start off with a generalization for energy. In the National Energy Policy Plan the Secretary has indicated that we are committed to a balance of nuclear, coal and conservation, those particular objectives, and, of course, other energy sources as well.

In terms of our environmental picture, we are looking to utilize our resources in an efficient and effective manner and maintain those options identified for the future while at the same time making sure we are, environmentally speaking, good neighbors, that we don't pollute, that we are in compliance with regulations, and beyond compliance, that we seek to reduce the risks we have identified from our operations whether it is a matter of compliance or not.

In that sense we are utilizing, developing our resources with the need for compliance and for reducing risk.

Senator EVANS. Do you feel that today the Department is attempting to take into full account the cost and the problems of environmental hazards associated with any energy source and in doing so thus able to really look at the economic relationships of one energy source to another?

I am thinking about if we are examining the economic viability of nuclear versus coal versus other resources, are we taking into full account the environmental hazards and the costs associated with the environmental problems of everything on nuclear from the pre-construction and construction and operations and waste handling and dismantling of plants and all of those things?

Are they really all being taken into account? On coal, are we doing the same thing in terms, to the degree we understand it, of the responsibilities for avoiding acid rain and other environmental hazards and in doing so, are we, in your view, fully up to speed in an honest evaluation of total cost and total environmental problems of one energy source to another?

Ms. WALKER. I will tell you what I know, sir, and that is——

Senator EVANS. Perhaps we need the Secretary here to answer that one.

Ms. WALKER. I will tell you that we are aware of the environmental cost of our operations to the extent that we understand the needs for environmental compliance generated by the various facilities, what those compliance features are going to be in terms of waste generated by various energy sources, and what the disposal costs are.

I have not seen a total cost comparison, for example, comparing nuclear energy to coal to other forms of energy such that from cradle to grave it is from the beginning of the initiation of the energy source to the end of it, whatever waste products generated, the total cost comparison.

I am aware of those costs. I agree with you that it is the kind of thing we should be looking at so that we do understand. We have been striving to maintain energy options for the Nation, minimizing the costs where we can and nevertheless seeking to comply with all environmental regulations.

I don't know that the decision to maintain these operations is strictly on a cost comparison basis alone because, obviously, there are other reasons for needing energy resources, but we are attempting to make comparisons.

Senator EVANS. I will probably ask the question of Dr. Trivelpiece when I get to him, but it seems to me that we are making some decisions, fiscal decisions, in the sense of priorities in terms of deferral by the Department and we have had a little to-do with the Secretary on this.

In the decision, do we simply cut back or eliminate all of the additions made by Congress in terms of energy resource, especially in other alternate forms of energy other than coal or nuclear?

I am curious as to how we can do that if we have not really done a thorough job of trying to totally analyze environmental cost as well as the other costs involved in the source.

I will give you a fair warning, Al, that I will ask that question when we get to you.

Out of curiosity, on page 3 you mention the Department has carried out its operational missions with a safety and health record that is two to three times better with respect to fatalities, injuries and illnesses and more than ten times better with respect to property protection, than that of the private sector.

Are you talking in specifics about one or several elements of the private sector that compare precisely with the kinds of things you are doing in the Department or is that a better record as compared with the overall safety and health record in the private sector?

Ms. WALKER. I believe that is across the board in terms of the average U.S. worker, but I would be happy to correct that if for any reason I am incorrect.

Senator EVANS. Does it make sense, is it fair to compare the overall safety records with the broad scope of the workforce when you are dealing with a fairly limited workforce involved in just certain areas of responsibility?

Ms. WALKER. I think it is fair with certain things in mind. For example, the standards that are set in terms of risk base standards for our industry are set with the same standard as that of other industries, industrial workforce. For example, I believe the National Safety Council has said the average accidental rate per year is 1 in 10,000.

So, the standards that the National Council on Radiation Protection sets are the basis for the same standard in DOE. In other words, that is the risk that can be assumed to be inherent and we strive to make sure that the risk is not greater than that in setting our standards. When we get to worker injuries, some of our very typical worker injuries, we are not talking necessarily nuclear related, but trip and fall accidents, it is very reasonable to compare them.

Where the industry is not different, where we might compare ourselves to NRC or commercial experience as opposed to DOE, our

rate is still better. I cannot tell you in every case that the jobs would be comparable. We believe that to the extent that our accident rate is better than all U.S. workers and better than the private sector and the commercial nuclear area, I believe those comparisons are valid.

Senator EVANS. We have to be careful that we are measuring equals.

In your technical safety appraisals you determine compliance with DOE safety requirements, industry lessons learned, and license facility requirements.

To what degree do you relate those at all to the activities of the NRC and how do you have that interrelationship or do you?

Ms. WALKER. We do in this sense. In several instances our orders adopt the NRC standards. In some cases they adopt them to the extent applicable to our facility, recognizing, of course, energy facilities are different, some are uniquely designed, for production not commercial power.

There are some differences that really make sense and, therefore, our regulations should be different. We do look to what the NRC is doing. As I indicated, in some sense we even adopt them, but others are not easily matched to our facilities.

Senator EVANS. Would you judge that the NRC, and we have to ask that question of NRC itself, would you judge, that NRC believes that it has sufficient information and contact that it would be satisfied with what is going on at our defense-oriented plants or has any real knowledge of what is going on?

In other words, would they have the same confidence?

Ms. WALKER. Let me say this. My staff coordinates to the extent that it is appropriate with the NRC staff. There is a lot of mixing. There are some ex-NRC people on my staff. There is exchange of information between the two. We are aware of what they are doing. Sure, they are aware of what we are doing.

We modeled the technical safety appraisals after the IMPO plant evaluations. To some degree, we have made ourselves more comprehensive. We have standards, some of which I am aware of are more conservative than NRC. To that extent, we may set limits for ourselves that are more stringent.

I think it is always a question of rising to the one standard that NRC has. I think there are differences that are meaningful and have to be observed. You would have to ask NRC whether they are pleased with what we are doing. Based on what I know of their record and ourselves, I couldn't say they would not be pleased.

Senator EVANS. Again, this question of whether we are talking about precise equals. We have two different sets of plants operating for quite different reasons and then substantially different circumstances. It may be too easy just to compare them across the board.

GAO's June 1986 report identified three defense facilities that do not have approved safety analysis reviews, Rocky Flat, Savannah River facilities, also identified inconsistencies in the degree of detail contained in the SAR's and criticized DOE for not obtaining independent reviews of SAR.

What is your comment about that report and what are you doing about it?

Ms. WALKER. I only just received the report last week, in fact, the evening before my hearing with Dr. Trivelpiece, at which Senator Glenn asked me about this very same thing, the report he caused to be prepared.

What I indicated then, and I indicate now, I have asked my staff to review this. I have asked them to give me a safety analysis report status beyond just the eight facilities, but of all our facilities.

As to the differences in the safety analysis reports, I am aware of differences in our facilities. We, ourselves, consider some of them to be high hazard facilities, others to be moderate or low hazard facilities. The analysis we do on the facilities varies for the risk involved. Without having the benefit of the full analysis from my staff, I can indicate there is justification for different levels of analysis in the safety analysis report.

Senator EVANS. Would you call Rocky Flats and Savannah River high, medium or low risk?

Ms. WALKER. I believe they are in the high and moderate risk category. If there are differences between them, I couldn't tell you at this time what the reasons for those might be, but we are definitely looking at it.

Under the new safety orders that we prepared since Secretary Herrington came to the Department, my office has independent review authority for the safety analysis report and concurrence in major decisions and as startups. I don't know whether the GAO report in saying something about independent review is speaking to a lack of review by an independent office that was established under Secretary Herrington or if they are speaking of something else.

Again, we have not completed our review of these. I will be happy to provide you with more information after that review is completed or to supplement the record.

[The information follows:]

DOE COMMENTS ON GAO REPORT
"SAFETY ANALYSIS REVIEWS FOR DOE'S DEFENSE FACILITIES CAN BE IMPROVED"
RCED-86-175

Following are the General Accounting Office (GAO) recommendations to the Secretary of Energy and the Department of Energy's (DOE) related comments.

GAO Recommendation 1

"We recommend that the Secretary of Energy

- o Complete and approve SARs for all high hazard facilities in a timely fashion."

DOE Comment

DOE concurs and will take action to assure compliance with this recommendation. All operating high hazard nuclear facilities have had a continuous history of safety assessments from the time of their original construction; however, some do not have a formal Safety Analysis Report (SAR) which has been formally approved by DOE. Even though controls deemed necessary for safe operation are specified by DOE approved Operational Safety Requirements, all SARs for existing high hazard facilities are scheduled to be reviewed and approved by the end of FY 1987. The Office of Environment, Safety and Health will track them to assure timeliness of completion.

GAO Recommendation 2

"We recommend that the Secretary of Energy

- o Require that SARs include a detailed comparison of the plant against current DOE design criteria, highlighting and explaining any deviations."

DOE Comment

DOE Orders require that safety analyses be based upon current technical criteria. Documentation of this is presented in the facility's Conceptual Design Report and/or in the applicable Design Criteria Document. These documents are used to systematically identify safety areas that warrant additional consideration in an SAR. DOE will require that such evaluations be incorporated into the SAR either through revisions of appropriate sections of the report or as an appendix. For existing SARs, this evaluation would be added at the time of the next normal update. Also, as part of the Secretary's initiatives, the Office of Environment, Safety and Health, which is independent of any operating responsibility for nuclear facilities, will be reviewing the SARs and supporting documents for major nuclear facilities. These reviews will include a comparison of the design against current DOE criteria. This will provide additional assurance that this DOE requirement is met and is appropriately documented in a consistent fashion. The above actions will ensure that the GAO recommendation is met.

GAO Recommendation 3

"We recommend that the Secretary of Energy

- o Develop more consistent requirements to be followed in preparing SARs, outlining appropriate methodologies and assumptions to be used in analyzing accidents and their consequences."

DOE Comment

One of the major objectives of the Secretary's new initiatives is to improve an understanding of and consistency in the implementation of the Department's overall Environment, Safety and Health program. With regard to the safety analysis and review process, this will be accomplished in two ways: first, updated and improved guidance will be provided; and second, the independent Headquarters Office of Environment, Safety and Health will review SARs. Additional guidance is being provided by this office through the recently published "Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities," January 1986, the soon to be finalized updates of the "Nonreactor Nuclear Facilities: Standards and Criteria Guide," the "Nuclear Air Cleaning Handbook," and the development of more detailed guidance for analyzing natural phenomena hazards, which is scheduled to be completed in 1987. This guidance will be incorporated into the DOE Orders, as appropriate. DOE will also develop guidance in the areas of SAR reviews and Operational Safety Requirements. Also, the Departmental requirements for new nonreactor nuclear facilities SARs have recently been updated to formally require consideration of appropriate NRC standard format and content guidelines. For DOE nuclear reactors this requirement has been in place for some time. The safety analysis and review process has been significantly enhanced by requiring concurrence by the Assistant Secretary for Environment, Safety and Health on the construction and startup authorizations of all new reactor and high hazard nonreactor nuclear facilities, and selected moderate hazard nonreactor nuclear facilities. Review and concurrence on significant modifications to existing facilities will also be required. In addition, about one-third of the approximately 120 high and moderate hazard operating facilities will be reviewed by the Office of Environment, Safety and Health. A sampling plan is being developed to select the SARs for review. The results of the first group of SAR reviews will determine if more than the pre-selected one-third need to be reviewed. These reviews will further assure that DOE facilities are consistently evaluated and compared against DOE design criteria and assure that uniform approaches and assumptions are utilized in the accident analyses presented in the reports.

GAO Recommendation 4

"We recommend that the Secretary of Energy

- o Establish an arrangement with an outside independent organization to review those SARs for the most hazardous facilities. This could be accomplished either by establishing a working arrangement with NRC or an independent review panel."

DOE Comment

Pursuant to Secretary Herrington's 1985 initiatives in environment and safety, an organization which is independent of any operating responsibility for DOE's production facilities, has been established to overview the Department's activities. That organization is the Office of the Assistant Secretary for Environment, Safety, and Health.

As part of the Secretary's initiatives, this independent organization will review the SARs for new high hazard and selected moderate hazard nuclear facilities within the DOE complex. Concurrence on the acceptability of these analyses by this organization will be required on the construction and startup authorizations. Also, as described above, independent reviews of select SARs for existing operating nuclear facilities are planned. With respect to the suggestion for a non-DOE review group, it must be noted that DOE has a variety of missions including research, development, and production. This diversity of facilities, operations, and functions has required the development and institutionalization of a dedicated cadre of scientists, engineers and operating personnel with a unique and internationally known capability to oversee and operate the DOE complex of facilities. This same expertise and capability are frequently called upon to provide technical guidance and first hand experience to support national and international bodies in developing safety rules and standards. Therefore, to establish an additional level of oversight, over and above that already existing under the guidance of the Assistant Secretary for Environment, Safety, and Health, would not provide any additional assurance of the safe operation of DOE facilities and would not be warranted in view of the expertise that already resides in the Department.

Senator EVANS. It would be helpful if you intend, and I presume you would, to respond to the GAO report. I would be happy to have a copy of that.

Senator FORD. There were reports, Mr. Chairman, in 1981 and 1983.

Senator EVANS. Mr. Ford.

Senator FORD. GAO made its report in 1981 and 1983 urging completion and approval of the reviews. We don't have that yet.

To back up, what the Chairman said about inconsistent approaches and the external independent review, why has it taken so long? Let us go back over that again.

Ms. WALKER. I will agree with you that is a concern of mine as well. I have asked my staff to provide me with analysis and justification and some indication of what remains to be done and how soon it can be done and what the schedule for that is.

I would be happier if you could wait until I have that before I provide you with an answer. I am afraid what I would give you now would be more general conjecture that would not be meaningful.

Senator FORD. How many facilities have an uncompleted safety review?

Ms. WALKER. I do not know the total. That is one of the questions I asked my staff. In the GAO report they identified two at Savannah River and one at Rocky Flat. There may be others. I want to make sure I have a correct answer for you.

[The information follows:]

The following high hazard nuclear facilities are being reassessed and the target dates for their corresponding review/approval are shown below:

Facility	Target date
1. Plutonium Fabrication,[1] Rocky Flats, CO	July 1987.
2. Polutonium Recovery, Rocky Flats, CO	July 1987.
3. Plutonium Manufacturing, Rocky Flats, CO	July 1987.
4. Reprocessing,[1] Savannah River, SC	October 1986.
5. Fuel Fabrication,[1] Savannah River, SC	September 1986.
6. Plutonium Processing, Savannah River, SC	November 1986.
7. Receiving Basin for Offsite Fuel, Savannah River, SC	September 1987.
8. Tritium Facilities, Savannah River, SC	February 1987.

[1] These facilities were identified in the GAO report.

Senator FORD. How is the public comment incorporated in the development of the review?

Ms. WALKER. I don't know in what manner the public comments are included in the safety analysis report. These reports, and I should indicate for your comfort level perhaps, are components, one aspect of the safety foundation upon which we operate our facility.

All of our facilities have completed and have in place technical specifications. Those are the foundation by which we operate our facilities in what we consider to be a safe manner. The safety analysis report, because it was an effort that came about at a time when many of the facilities had been operating for several years, is an attempt to go back and reanalyze the risk inherent in the operation.

It is really a very technical level, including probabilistic risk assessment and that sort of thing. I don't know if at that technical level they would be including public comments.

Senator FORD. Are you telling me you have no control over this, that you don't understand what goes in it or what is being done or how the process is developed?

Ms. WALKER. What I am telling you is that I am not aware of what public input there may be.

Senator FORD. You are not aware of the full procedure of the review?

Ms. WALKER. That is true. I am not aware whether the public is involved in the safety analysis report itself. I know the facilities incorporate public concern when they look at the facilities. I am not sure if it is part of the process or not.

Senator FORD. Who is in charge of the process? Who is responsible?

Ms. WALKER. The field offices.

Senator FORD. Under whom?

Ms. WALKER. It would be under the program. It would not be under my office. I have independent review authority, but they are not prepared under my office. The field office would prepare them.

Senator FORD. Would the field office then send it up to you?

Ms. WALKER. It would come up to me for review. It would also be reviewed by the various programs. If it were defense production reactors at Hanford, I imagine it would come up to them for review.

I would have independent review and have concurring authority on the finalization, such as startup of a facility.

Senator FORD. In your opinion, should the public be included in the review process?

Ms. WALKER. The safety analysis report and its assessment of the risk inherent in the operation, I don't know that that is something that necessarily should involve a public review. The public is included, for example, in all of the environmental assessments and where they want public comment——

Senator FORD. The public is not interested in the safety? What about the State responsibility, the Governor of the State of Washington?

Ms. WALKER. I am not suggesting they should not be included in the sense they should be made aware of it and it should be submitted to them for review.

I am saying in terms of the technical assessment of the risk, I don't know if that is something that appropriately involves the public. Again, this is something that I am looking at. I can't tell you I wouldn't make a recommendation. I am not precluding the fact it may be. I am just not aware of it.

Senator FORD. Something disturbs me about this. Supporters of nuclear power have reacted to the Chernobyl accident by pointing to the open regulatory process in the United States that is supposed to ensure the safety of the commercial nuclear powerplants. However, DOE nuclear facilities are outside the regulatory scheme.

Is the system we are now using to regulate DOE nuclear facilities self-regulating?

Ms. WALKER. It is self-regulating to the extent we are not under NRC. There are good reasons for as well as against having NRC

regulate this activity. It is not a closed process. DOE orders are available for public inspection, technical safety appraisals are available, et cetera.

They can be made aware of all aspects of our safety programs. I don't believe the process is intended to exclude them or a process they cannot avail themselves of, just because it is different from NRC's.

Senator FORD. They can know about it, but there is nothing they can do about it, that is the difference. This is a State-run or Federal Government-run facility that the public can know about, but cannot do anything about because they have no input.

All they can do is receive the technical report and that sort of thing. They might come up and scream a little bit and maybe we will do something about it, but it is basically the Chernobyl situation, the public had no input, DOE runs it. There is no State or public input according to you as it relates to safety review.

Ms. WALKER. I don't believe that is correct, Senator. What I was saying in the one particular aspect of our safety process, in the safety analysis report, I am not aware of what level of public involvement is included.

I would like to supply that for the record because I don't want to misinform you.

In terms of our safety and environmental reviews of our safety and the public concern, they are very much involved in the process, not only through the States and our meetings through the States, but the field offices all maintain an active liaison with the local community.

In many instances they even have advisory groups of citizens set up to meet with them on a regular basis. I don't believe you will say the public is not involved. It is usually at the field level, not at the headquarters level at my shop. I am an independent oversight department.

[The information follows:]

DOE provides an opportunity for public comment on operating and proposed facilities through its field offices and through the NEPA process for new projects and major changes. One example of field office/state/public interaction is the reviews of the Rocky Flats Plant. The DOE interfaced with a committee established in 1981 by Governor Lamm and Congressman Wirth—the Blue Ribbon Citizens Committee (BRCC) on the safety of the Rocky Flats Plant. DOE provided briefings, tours, and safety reports to a State of Colorado citizens committee consisting of prominent lawyers, physicians, educators, and representatives of consumer groups. DOE interacted with the BRCC for several years and a finial report was issued by Governor Lamm which provided health and safety and other recommendations to DOE. In general, DOE uses the NEPA process as a mechanism to obtain public comments on environmental and safety concerns. Normal operation and accident evaluation are assessed. The EIS provides an excellent forum to debate the issues since it is looking at the effect that proposed operations will have on man and th environment.

Senator FORD. If you have independent oversight, you know what input went into the review.

Ms. WALKER. I have to tell you that I have not been fully briefed on the safety analysis report nor have I had a chance since I came into office to fully analyze the whole system. That is in process right now. I would like to be able——

Senator FORD. How long have you been in office?

Ms. WALKER. Since the end of December.

Senator FORD. I have some other questions about what you said you would do at the time of your nomination hearing. I will wait and ask about those when you have had time to understand the office that you are in.

Thank you, Mr. Chairman.

Senator EVANS. Thank you.

Senator WARNER. Mr. Chairman, I would like to put my question to Dr. Trivelpiece.

Senator EVANS. We have not heard his testimony yet.

Senator WARNER. He and I have been working for many years on CEBAF. I am encouraged to see in his testimony on page 19 that he categorizes this project as the high priority basic research in the United States. I think you have a strong budget program this year. As near as I can determine, the program is well underway.

Do you concur in those observations?

Dr. TRIVELPIECE. Yes.

Senator WARNER. A simple answer to a direct question.

I thank the chairman and I thank the witness.

Senator EVANS. Senator Hecht.

Senator HECHT. Thank you. I have no questions.

Senator EVANS. I have just one more question, I guess two more for Ms. Walker.

On page 10 of your testimony you state: "We are participating in analyses relating to regional and global environmental issues such as acid rain, climatic change, deforestation and nuclear winter."

You are participating in them.

What do you do in participation?

For instance, there is a good deal of concern expressed about the apparent depletion of ozone on a seasonal basis in the Antarctic. Presumably that falls in the category of some of the things you mentioned.

If you participate, what becomes of the participation? What lines of communication, what recommendations do you make of these?

Ms. WALKER. It depends on the level of participation. In some cases another Agency, or another office may have the primary role in the research. We may participate to the extent of participating in the analysis, or even in the acid rain area, perhaps in the research portion.

These efforts may be followed together such as NAPAT, and we participate with other agencies. The findings, whether analysis from my office or research from another component of the Department, are made available and perhaps, for example, in the acid rain area through the NAPAP process made available to the other agencies and to the public.

If it is a report where we have actually drawn together existing information or, in addition to that, added some of our own analysis, we may publish the report. I am aware of one we recently did on radon, for example, and that has been made available.

Senator EVANS. In each of these cases of broad, or global environmental issues, has there been a lead Agency assigned from the Federal Government, in each of these areas or are we involved there?

Ms. WALKER. I think of a lead Agency as even being the Agency having the largest component of research. You might think of EPA

as having the lead in some areas or, we may have smaller pieces. In some of the environmental areas, that may be true.

Dr. Trivelpiece may be able to comment on the area of research.

Senator EVANS. Let us take acid rain.

Would that be primarily an Energy Department activity or EPA?

Ms. WALKER. I think most of the research budget comes from EPA.

Dr. TRIVELPIECE. It is divided among several agencies, NCAA, Commerce, Agriculture and Department of Energy. It depends on whether or not you include control technology or not. The research part of it is split fairly evenly among agencies, but EPA has the largest amount.

Senator EVANS. How about climate?

Dr. TRIVELPIECE. On CO_2 the Department of Energy is the lead Agency and of the $23 or so million dollars, $13 million of it is spent by the Department of Energy for various programs related to CO_2. The others are Dept. of Agriculture and NSF, I think is the other principal.

Senator EVANS. On climate change, do you have a primary responsibility? Do you have a regularized reporting of a year's work or at some regular interval?

Dr. TRIVELPIECE. There are periodic reviews among the various agencies doing CO_2 research. Just recently four so-called state-of-the-art reports have been prepared. We will be glad to make those available to the Committee.[1] They describe in some considerable detail what we know about carbon dioxide, its sources, sinks, the likely effects on climate.

They are very comprehensive. They have just been issued. They are the result of CO_2 programs, guidance through the Department of Energy.

Senator EVANS. How about deforestation? That is sort of related to CO_2 as a matter of fact.

Dr. TRIVELPIECE. The state-of-the-art report indicates that deforestation is probably less than 20 percent of the cause of CO_2 build-up. It is mostly due to the burning of fossil fuels.

Senator EVANS. Who would have primary responsibility for deforestation and whatever other adverse effects come from deforestation?

Dr. TRIVELPIECE. I am not sure what you mean in the sense of responsibility for it.

Senator EVANS. Responsibility for the analyses or studies, or whatever is going on, or do we care?

Dr. TRIVELPIECE. Yes. The Department of Energy does have the responsibility for taking the lead in that. However, we do work with the other agencies that I have mentioned.

Senator EVANS. How about nuclear winter?

Dr. TRIVELPIECE. I think NCAA was given the lead for nuclear winter. It has been coordinated through that office.

Senator EVANS. How about ozone depletion?

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[1] The reports have been retained in subcommittee files.

Dr. TRIVELPIECE. The research is being done by several entities, several agencies, but through section 125 of the Clean Air Act, I believe that the EPA has the lead responsibility for that.

Senator EVANS. Ms. Walker, your budget authority in the 1987 request goes up by almost $30 million which is a pretty hefty increase, about 60 percent increase, and your staffing goes up by 2 FTE's. That is $15 million per employee.

What else are you spending the money on?

Most of that money is environmental audit and compliance. It sounds to me like environmental audit and compliance takes a lot of staffing to do the contract.

Ms. WALKER. The majority of the increase for 1987 is for the environmental survey. The majority of that, about $28 million, is for the sampling and analysis components. The environmental survey is run out of and led by the Office of Environmental Audit and Compliance which is a brand new office and is essentially being staffed up this year.

I think we have about 20 or 22 individuals in that office right now. The majority of the members of that office will be the team leaders and assistant team leaders for the 5 survey teams going out. They will be supplemented by membership on the teams from contractor sharing specific expertise in areas such as hydrogeology, chemistry, biology, and various components of the environmental protection specialists that we need to accomplish the survey.

The majority of the money is for the survey. The majority of that is for the sampling and analysis portion of it. The sampling and analysis will be conducted by contractors under supervision of that office.

Senator EVANS. When you say that office, that office is not included within this summary.

Ms. WALKER. The Office of Environmental Audit and Compliance should be.

Senator EVANS. It is. It shows a large increase in the budget, but it does not show any corresponding increase in the whole office in staffing. That is on page 11 of your testimony.

If you are staffing up, I would expect that with the 1987 staffing, the chances are it will be a big year. If it is all being done by contract, being done by somebody outside, the two don't seem to match.

Ms. WALKER. In 1986 I am advised that office in total numbers went from 101 total staff in my office to about 125 FTE's in fiscal year 1986. The majority of that was for the Office of Environmental Audit and Compliance. There is an additional increase asked for in 1987.

Senator EVANS. That does not sound right because your staffing is in terms of FTE's. You show 125 FTE's in fiscal 1986.

Ms. WALKER. That is right. It went from 101 to 125 in 1986.

Senator EVANS. 101 to 125, the average couldn't be 125. I have always thought an FTE was one full person for one full year. You could not have gone from 101 to 125 and get an average of 125.

Ms. WALKER. If you could ask my office director to answer your question. I am not as good with FTE's. There is a distincton between the onboard strength and FTE. His name is Geoff Judge.

Mr. JUDGE. My name is Geoff Judge, acting director of the Office of Budget and Administration in Mary's office.

I am not sure I understand exactly what your question is.

Senator EVANS. First, tell me what is your understanding when you say staffing of FTE's, fiscal 1986, 125. What does that represent?

Mr. JUDGE. Full-time equivalents.

Senator EVANS. For that year you had essentially an average of 125 people working all year long?

Mr. JUDGE. Correct.

Senator EVANS. You said that the number of people onboard went from 101 to 125.

Mr. JUDGE. We started out in fiscal year 1986 with 101 people onboard. We currently are at a staffing level that is approximately 139 full-time employees.

Senator EVANS. That is a new figure that we have not heard about.

What is it intended to be? Are you going to drop to 125 employees for fiscal 1987?

You have 139 onboard now. What will you do with 139 people next year?

Mr. JUDGE. Our FTE request for fiscal year 1987 is 125.

Senator EVANS. You have 139 onboard now. You will have to fire somebody.

Mr. JUDGE. We have a normal attrition rate that runs in the neighborhood of six employees or thereabouts per quarter. There is also the possibility of adjustments in FTE's being made as we go through the fiscal 1988 internal review budget process within the Department.

Senator EVANS. What is the rationale for going from 101 to 139 and back to an average of 127?

Ms. WALKER. I would have to say we are looking for an onboard strength greater than 127 eventually. With our attrition rate and retirements we have had, we may be at that level, even given the number of people we have onboard now.

Ultimately to carry out the functions, we will probably be requesting additional numbers.

Senator EVANS. To carry out the budget request you have made, you are going to come back and ask for additional people?

Mr. JUDGE. If we find that the workload requires it, yes, sir.

Senator EVANS. That would require more money?

Mr. JUDGE. Perhaps.

Senator EVANS. A supplemental budget?

Mr. JUDGE. The amount of money that would be involved, it is doubtful if it would require a supplemental budget.

Senator EVANS. I think you had better present for the record a better explanation of that, the changes in FTE's and how they relate to the budget request and what you think you may have to have. I have seen that too many times from too many agencies that the budget request comes in at one level and the FTE's come in at a level and it is known within the agency that at some time in that year you are going to have to send a request for a supplemental.

I think we ought to know that from the beginning. So, will you let us know what your expectations are, what it will take to carry

out the budget request that you have made, so that we can honestly see how many people it will take and what kind of supplemental it will require to carry out that function?

Ms. WALKER. We will be happy to supply that information.

Senator EVANS. Thank you.

[The information follows:]

The approved FY 1986 staffing level for the Environment, Safety and Health program was 110 fulltime equivalents. This FY 1986 staffing level was subsequently increased to 125 fulltime equivalents from within existing Departmental resources to allow work to begin in FY 1986 on the Secretary's new environment, safety and health initiatives. The FY 1987 budget request for a staffing level of 127 fulltime equivalents represents a further increase of 2 fulltime equivalents. As of June 21, 1986, we have 139 fulltime employees in the Environment, Safety and Health program. While we currently believe that our staffing requirements will exceed our FY 1987 budget request, it is the Department's expectation that this increase can be managed from within existing Departmental resources and thus, a supplemental would not be necessary.

Senator EVANS. Senator Domenici.

Senator DOMENICI. First, let me thank you for accommodating me and helping me out by chairing.

I have a number of questions, but I believe I will reserve them for Dr. Trivelpiece. I believe he will put his testimony on; is that correct?

Senator EVANS. We are at that point right now unless you have questions before.

Senator DOMENICI. I have not. I will wait.

Senator EVANS. Thank you very much. We are happy to have you here.

I will turn to Dr. Trivelpiece for his testimony.

STATEMENT OF DR. ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Dr. TRIVELPIECE. It is a pleasure to be here before this committee. The programs that are here I have had the opportunity to talk to you about many times in the past.

I have made no secret of the fact that I feel these programs that are managed within the Office of Energy Research are essential elements in the Nation's science and technology enterprise, some $2 billion worth of them.

They span a space that goes all the way from such things as trying to understand what the fundamental constituents of matter are, what the forces are that influence them, to applied programs that seek to develop new energy sources such as the fusion program.

They range from things that involve bench science activities at universities from single investigators to large programs such as those at the Fermi National Laboratory in high energy physics, and such as the synchrotron light source at Brookhaven National Laboratory.

The programs that go along with this have been important to the Nation. They have, I believe, repaid themselves many times over, such things as nuclear power, nuclear medicine, and so on, relate to things that have their watershed in present and previous DOE Programs.

In a program of this size it is hard to pick something to emphasize. I would like to pick something that is probably the smallest element in the budget and something you have not heard about, at least not in the form of hearing since I appeared before this committee last.

Secretary Herrington has repeatedly asked me what we can do about trying to use the DOE facilities as an element in stimulating interest on the part of high school students and others in careers in science and engineering.

Last year, as a result of some suggestions that were made, we invited the Governors of each State as well as the District of Columbia and Puerto Rico to identify a high school student, a junior or senior that they regarded as being the very best in areas of science, computer science in particular.

We took those 52 students and had them go to the Lawrence Livermore Laboratory for 2 weeks last year and work on the Cray supercomputer there to gain experience and sense some of the excitement of what it is like to work in such a facility.

The program went extremely well in spite of some apprehension about what Super Kids, as we now call them, would do when they got hold of passwords on the Cray computer. Nothing bad happened. Good things happened. One of the good things that happened is that 19 of those high school students have been offered and accepted summer jobs to work at Livermore this summer.

In addition to that, the Department has sponsored this program again this year at Livermore and the students have been selected, but it has also been expanded. The Super Kid Program has been expanded to permit another 52 to go up to the Brookhaven National Laboratory and work at the synchrotron light source up there and gain some hands-on experience working in that kind of facility.

We hope to be able to expand this further to additional labs in the future. It seems to be playing a very important role. In that sense the Department of Energy is not just one dimensional in that it works only on energy processes, but it does play a role in the educational enterprise as well.

Many students receive their education as a result of activities supported through the Department and with the chairman's help in the past, we have also now implemented a program in which industrial scientists can spend brief periods of time at the labs and also postdoctoral programs are taking place.

These are extremely important aspects of the Department, although, compared to the other elements of the budget, quite small.

That concludes my opening remarks. I will be glad to answer any questions.

I presume my prepared statement is included in the record.

Senator EVANS. Your entire statement will be included in the record. It has a good and detailed description of your programs under your responsibility.

[The prepared statement of Dr. Trivelpiece follows:]

Statement of Alvin W. Trivelpiece

Director

Office of Energy Research

Department of Energy

before the

Subcommittee on Energy Research and Development

of the

Senate Committee on

Energy and Natural Resources

June 23, 1986

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear here today to present the FY 1987 budget request for several of the programs supported by the Office of Energy Research (ER). These programs are: High Energy and Nuclear Physics, Basic Energy Sciences, Magnetic Fusion Energy, Biological and Environmental Research, Energy Research Analysis, University Research Support, University Research Instrumentation, and Multiprogram Energy Laboratories-Facilities Support. The High Energy and Nuclear Physics programs are under the General Science and Research appropriation. All of the other programs are under the Energy Supply R&D appropriation. The FY 1987 budget request for all ER programs is shown in Table 1.

At this point I would like to discuss each of the programs mentioned above in some detail.

HIGH ENERGY AND NULCEAR PHYSICS

The High Energy and Nuclear Physics programs seek the answers to questions that man has asked for many hundreds of years, namely, what are the basic constituents of matter and what forces govern them. While continuing to seek answers to those questions, the High Energy and Nuclear Physics programs have made significant contributions not only to energy resource development, but to education, health, industry and national defense. Contributions to the economic growth and prosperity of the Nation have come directly from the results of the research, from technological spinoffs and from the training of tomorrow's scientists through participation of university graduate students in the research. Through science and technology transfer, these ideas and people have made contributions to a variety of industries including medical instrumentation and therapy, control and instrumentation of industrial processes, the production of nuclear energy, and many applications of electronic and computer techniques.

Table 1
Office of Energy Research
Summary by Program
($ in millions)
Budget Authority

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
General Science & Research				
High Energy Physics	$541.9	$517.1	$494.8	$546.7
Nuclear Physics	181.5	171.9	164.5	224.2
General Science Program Direction	2.2	2.4	2.1	2.5
Transfer of Appropriation	0	- 6.0	- 6.0	0
Subtotal	$725.6	$685.4	$655.4	$773.4
Energy Supply - R&D				
Basic Energy Sciences	$410.8	$450.8	$433.8	$441.4
Magnetic Fusion Energy	429.6	379.8	365.5	333.0
Biological & Environmental Research	187.7	187.0	179.9	196.6
Energy Research Analysis	3.0	2.7	2.6	3.5
University Research Support	10.1	10.7	10.3	11.0
University Research Instrumentation	4.9	6.5	6.2	5.0
Multiprogram Energy Laboratories-Facilities Support	33.2	42.1	39.8	60.2
Advisory & Oversight Program Direction	2.9	2.8	2.7	2.9
Policy and Management	0.5	0.1	0.1	0.5
Subtotal	$1,082.7	$1,082.5	$1,040.9	$1,054.1
Total ER	$1,808.3	$1,767.9	$1,696.3	$1,827.5

The High Energy and Nuclear Physics programs are closely related not only in terms of overall goals, but also in the types of facilities and equipment used to reach these goals and the impact that research in one program has on the other. Both seek to contribute to an understanding of the basic constituents of matter and the forces that govern them. Nuclear Physics does so by studying the nucleus; High Energy Physics does so by studying the most fundamental of particles that comprise the nucleus and all other matter.

Experiments in both the High Energy and Nuclear Physics programs depend on large experimental facilities that accelerate beams of particles to collide with stationary targets or head-on with other moving particle beams. Studying the results of these collisions helps scientists to learn about the properties of the underlying building blocks and basic forces involved. Although research progress depends on the availability of these forefront accelerator and colliding beam facilities, as well as on the detectors that record the results of the collisions, progress also depends on a continuing interplay of advancements in experiment, theory and technology. Often the range of experiments possible is determined by available technology; and physicists frequently have to invent new equipment and technology to carry out the most important experiments.

In the High Energy Physics program, research utilizing accelerators is conducted principally at four accelerator laboratories in the U.S., two in Europe and one in Japan and encompasses more than 150 user groups. The Nuclear Physics program, carried out at seven national facilities, accommodates approximately 70 user groups. The program also utilizes facilities in Canada and Europe.

HIGH ENERGY PHYSICS

Progress toward improving our understanding of the fundamental nature of energy and matter and their most elemental transformations has come rapidly in recent years. In developing this knowledge, five U.S.-supported high energy physicists have won or shared in Nobel prizes during the last seven years. The major current objective of high energy physics research is unification of the basic forces of nature into a single theoretical framework; in other words, a single theory that would describe all of the interactions of matter and energy existing in the universe.

The electromagnetic force describes how atoms and molecules are formed and is the cornerstone to understanding chemistry, electronic communications and biological processes. The weak nuclear force describes processes such as the radioactive decay of nuclei. The strong nuclear force holds the nucleus together and helps describe how the sun and the stars produce so much energy. Together with the weak nuclear force, it also describes the relative abundance of the chemical elements. The gravitational force, perhaps the most familiar of the forces of nature, explains such things as how objects fall and planets move in their orbits.

Results of high energy physics research have led to an increasingly better understanding of the forces of nature and the unifying connections among them. A part of the recent progress in high energy physics has been the conceptual unification of the weak nuclear and electromagnetic forces into a single "electroweak" framework. In addition, a theory of the strong force has emerged which is consistent with observation. There is increasing anticipation that the unification of the strong nuclear and electroweak

forces into one "grand unified" framework may be possible, thus reducing the apparent number of forces in nature to two. The ultimate goal is a "super-grand" unification that would bring all of the forces in nature into a single unified framework.

The picture of nature composed of the electroweak and strong forces and a small set of fundamental constituents is known as the Standard Model. The most significant recent experimental results all reinforce the predictions of the Standard Model. Although no deviations have been found from it, scientists believe that the Standard Model cannot be the final answer because it does not explain the origin of mass and it does not include gravity (one of the four forces of nature). Experiments are being prepared to use the new capabilities coming into operation in early FY 1987 and the near future to search for phenomena which do not conform to the Standard Model and in particular for phenomena predicted by grand unified theories.

Before I discuss the budget request, I would like to report on some of the recent and ongoing accomplishments in the High Energy Physics program. The Fermi National Accelerator Laboratory (Fermilab) Tevatron, the world's first high energy accelerator using superconducting magnets, provided beam for numerous experiments with protons at energies up to 800 billion electron volts (GeV) in 1984 and 1985. The substantial quantity of data recorded in the very productive 1985 run is now being analyzed. The new antiproton source for colliding beam experiments has been successfully tested; and in FY 1987 the accelerator is expected to operate at energies near 900 GeV per beam for both fixed target and colliding beam experiments.

The Alternating Gradient Synchrotron at Brookhaven National Laboratory (BNL) is doing experiments with the world's highest energy beam of polarized protons and high intensity beams of particles referred to as kaons for precision studies of rare kaon decays.

Substantial progress is being made on fabrication and installation of the Stanford Linear Collider (SLC) at the Stanford Linear Accelerator Center (SLAC). Successful development of the SLC will provide an essential demonstration of the technical feasibility of using linear accelerators with precisely controlled high intensity and highly focused beam pulses to provide high rates of electron-positron collisions at energies far beyond those that will be affordable for circular colliders. It will also permit significant new physics experiments with 50 GeV on 50 GeV electron-positron colliding beams. Systems tests are scheduled to begin later in FY 1986, and the first 50 GeV on 50 GeV colliding beam experiments are planned early in 1987.

FY 1987 HIGH ENERGY PHYSICS BUDGET REQUEST

The FY 1987 request for the High Energy Physics program is $546.7 million, which consists of $427.5 million for Operating Expenses, $77.5 million for Capital Equipment and $41.7 million for Construction (Table 2).

A major part of the funding for the program is required to meet the direct needs of the accelerator laboratories to develop, maintain and operate the major accelerator, colliding beam and detector facilities. The high energy particle accelerator and colliding beam facilities to be operated by the Department in FY 1987 include: the Tevatron superconducting magnet proton synchrotron at Fermilab providing proton beams of about 800 GeV and numerous

Table 2
High Energy Physics
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses				
Physics Research	$106.3	$111.0	$106.3	$118.6
Facility Operations	172.7	183.1	175.1	213.4
High Energy Technology	90.2	92.4	88.4	95.5
Subtotal	$369.2	$386.5	$369.8	$427.5
Capital Equipment	58.7	73.1	70.0	77.5
Construction	114.0	57.5	55.0	41.7
Total High Energy Physics	$541.9	$517.1	$494.8	$546.7

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secondary beams for fixed target experiments; the 50 GeV linear electron accelerator at SLAC providing injected beams for the Positron Electron Project storage ring (15 GeV on 15 GeV) and for the SPEAR storage ring (4 GeV on 4 GeV), and the 30 GeV proton synchrotron, the Alternating Gradient Synchrotron (AGS), at BNL. In addition, Fermilab's collider and detector (900 GeV on 900 GeV proton-antiproton collisions) and the SLC collider and Mark II detector at the SLAC (50 GeV on 50 GeV electron-positron collisions) will operate for research for the first time in FY 1987. Each of these DOE accelerator centers provides a unique set of experimental research capabilities, complementary to the others.

The facilities at these laboratories provide the source of experimental data for most of the High Energy Physics research, more than 75% of which is carried out by university-based scientists. In addition to research carried out using high energy accelerators in the U.S., the Department's High Energy Physics program supports experiments which use the capabilities of unique foreign accelerators and also some experiments which do not require beams from particle accelerators.

The FY 1987 request for operating expenses is $427.5 million. The major features of the program in FY 1987 will be, as mentioned earlier, the first operation for research of the 900 GeV on 900 GeV proton-antiproton colliding beam capability provided by Tevatron I, and the 50 GeV on 50 GeV electron-positron colliding beam capability provided by the SLC. There are major incremental costs associated with operation of the new, world forefront Tevatron and SLC collider facilities. These two new research capabilities

ensure a world competitive position for the U.S. program. The request brings these new research facilities into operation and accommodates an overall facility utilization level near 50 percent. The request also provides continuing support for university-based groups including U.S. user group efforts at U.S. and foreign accelerators, non-accelerator experiments, and theoretical research efforts. In addition, the FY 1987 program includes funding for a continuation of advanced technology accelerator and detector R&D. I will make some specific remarks about the Superconducting Super Collider (SSC) after I have completed summarizing the High Energy Physics budget.

The FY 1987 capital equipment request of $77.5 million meets the highest priority needs for detectors required to implement strong and effective research programs based upon the new capabilities provided by the Tevatron proton-antiproton collider at Fermilab and by the SLC electron-positron collider at SLAC. The equipment request for FY 1987 is essential to make it possible for the D-Zero detector at Fermilab and the Stanford Linear detector at SLAC to be completed in FY 1989, thus permitting the most effective use of the new facilities at these two laboratories.

The FY 1987 request for construction funds is $41.7 million. The projects are listed in Table 3. This request includes continued work on upgrading the central computing capability at Fermilab ($14.1 million) which is required for the analysis of the large volume of new physics data coming from the Tevatron program, continued construction of the AGS Accumulator/Booster at BNL ($3.5 million) and continued construction to complete the SLC ($1.0 million) and Tevatron I ($0.4 million).

Table 3
High Energy Physics
Budget Authority
($ in millions)

	FY 1987 Request	TEC	Completion Date
Construction			
Tevatron I (81-E-218)	$ 0.4	$ 84.0	FY 1987
Stanford Linear Collider (84-ER-133)	1.0	115.4	FY 1987
Central Computing Upgrade, Fermilab (86-R-104)	14.1	24.1	FY 1988
AGS Accumulator/Booster, BNL (86-R-105)	3.5	26.4	FY 1989
Accelerator Improvements and Modifications Project (87-R-101)	11.5	11.5	FY 1989
General Plant Projects (87-R-102)	11.2	11.2	FY 1989
Total Construction	$ 41.7		

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Funds are requested for Accelerator Improvement and Modifications Projects ($11.5 million) that are critical to maintain the scientific effectiveness and the operating reliability and efficiency of the accelerator and colliding beam facilities. The request also provides $11.2 million for General Plant Projects (GPP) which are required to keep the general plant of the laboratories (e.g., buildings, roads, utilities) in operating condition.

This brings me to the SSC, which has been the subject of great interest, both in the scientific realm and in the public realm. I would like to state briefly where we are now and what the Department's plans are with regard to the SSC.

As I indicated in my discussion of accomplishments, excellent progress has been achieved in recent years in improved understanding of the fundamental constituents of matter and the basic forces that influence their behavior. Physicists now have the Standard Model which provides a framework within which these things can be viewed consistently. However, the Standard Model is not the final answer. Many very fundamental questions, such as the origin of particle masses, cannot be answered within the theory. There is much left to do.

The facility upgrades nearing completion at Fermilab and SLAC will provide two world forefront research capabilities into the 1990's which will permit exploration in new physical domains and exciting new discoveries. However, these research capabilities cannot explore the trillion electron volt (TeV) mass scale where breakthroughs in fundamental understanding and new

phenomena are expected. Access to the TeV mass scale would definitely test many key features of the Standard Model, and would permit exploration of a new domain never before explored.

In late 1983, the Department developed a plan to initiate preliminary R&D related to an SSC. This R&D program was to carefully assess costs, examine cost-reduction opportunities, and resolve technical and design issues, thus providing crucial input upon which to base an informed judgment about proceeding with the SSC at an appropriate time. The activities begun in FY 1984 have been continued into FY 1985 and FY 1986.

The accelerator R&D related to the SSC initiated in FY 1984 was achieved as a redirection of efforts from earlier planned accelerator R&D. The 1984 work included R&D on technical options (particularly with regard to superconducting magnets), cost reduction studies, and a Reference Designs Study (RDS) which established technical feasibility and developed credible preliminary cost and schedule estimates. Research and development activities in FY 1985 included R&D to confirm RDS assumptions; cost reduction studies; further R&D on superconducting magnet designs to provide the technical basis for selection, near the end of that fiscal year, of the magnet type which would yield the best performance at the lowest facility cost; studies to develop a cost/performance optimized design; and development of a technical site criteria report. The technical progress of the R&D activities has been excellent. Critical milestones have been met. In FY 1986, SSC-related research and development includes advanced accelerator R&D to develop a cost/performance optimized design for the selected type of superconducting magnet, to develop cost-effective

techniques for fabrication of full length superconducting magnets, and to develop conceptual systems designs. This program will provide the technical information for an indepth Departmental review of the SSC this Summer. Although a continuing R&D program is required in FY 1987, the direction and emphasis of the program, especially the work on superconducting accelerator magnets and associated systems, will depend on the results of this review.

NUCLEAR PHYSICS

The Nuclear Physics program supports basic research necessary to identify and understand the fundamental features of atomic nuclei and their interactions. Nuclear processes guide the evolution of the universe, cause the sun to give off energy, and demonstrate the interplay of three of the four primary forces of nature - the strong force, which holds the nucleus of the atom together, the electromagnetic force, which holds together not only the atom but also the many chemical substances we are all familiar with, and the weak force, which like the strong force, is found only in nuclei. The weak force controls, among other things, the generation of beta rays from nuclei. The study of nuclear physics consequently lies at the core of the processes which control our universe.

In terms of trained manpower, new knowledge, and advanced instrumentation, the Nuclear Physics program continues to be a vital factor in America's long-term investment in its technological future. Nuclear knowledge, techniques, instruments, and applications are an integral part of American society. Nuclear science and technology serve as the basis for our national

defense strategy, for therapeutic and diagnostic medical applications, for generation of electricity, and for a large and diverse array of applications in industry.

The Nuclear Physics program provides the major support for basic research in nuclear science in the United States. Through major accelerator facilities, which are really giant sophisticated microscopes that allow us to "see" into the nucleus of the atom, and through support of theoretical investigations, the program assures that the United States is at the forefront in the discovery of new knowledge in the field of nuclear physics.

Recently, new theoretical insights have opened the door to a more profound understanding of nuclear matter. Indeed, the basic understanding of nuclear structure used over the last 50 years is now being modified. Neutrons and protons, the constituents of the nucleus that we all learned about in school, are now known to be composed of smaller constituents called quarks. Nuclear theorists, along with high energy theorists, are investigating the ways quarks are confined together in groups of three to make neutrons and protons. In addition, a more fundamental theory of the strong force, which holds the nucleus together, is emerging based on these new understandings. This new theory, called quantum chromodynamics, is altering in major ways our understanding of nuclear matter. Exploring these new concepts in depth will require higher energy probes than have been available to the Nuclear Physics program up to now.

Before turning to the budget request, let me summarize several Nuclear Physics accomplishments of the past year. They illustrate the kinds of accomplishments that contribute to our ever-increasing knowledge of nuclear physics and, thus, of the processes that control our universe.

o The best quantitative measurements presently available to test the theory that protons and neutrons are made up of quarks come from precision scattering measurements using high energy beams of electrons and particles called muons, which have very short lifetimes. The muon, which behaves very much like an electron, is used as a probe of the nucleus.

  Results of these precision experiments have given detailed information about quarks and their motion within neutrons and protons. Recently the European Muon Collaboration (EMC) at the European Center for Nuclear Research (CERN) used muon beams to bombard nuclei spanning the periodic table from hydrogen to uranium. Results showed that muons scattered differently from quarks bound inside nuclei than from quarks in free protons and neutrons. This unexpected observation has been verified and extended by research at the Stanford Linear Accelerator Center. A number of nuclear models have been proposed to explain this effect. Since each of these models can explain the existing data, it is important to test the differences identified in the various models with further experiments. An experiment using proton beams at the Los Alamos Meson Physics Facility (LAMPF) now appears to rule out one of the possible interpretations. Another study at the MIT Bates Electron Accelerator Laboratory suggests that the interplay between the movement of quarks and the bulk nucleus in which they are contained may be more important than previously realized.

- A heavy ion is a relatively large or heavy nucleus which is electrically charged so that it can be accelerated. In the field of heavy ion nuclear physics, heavy nuclei are bombarded with heavy ions. During such collisions a distribution of very high energy and high density nuclear matter created. In collaboration with the Laboratory for Heavy Ion Research at Darmstadt, West Germany, and the Universities of Frankfurt and Heidelberg, Yale scientists have discovered the production of positrons (positively charged electrons) with well-defined energies resulting from such heavy-ion collisions. This unexpected phenomenon has not been explained so far. It has been suggested that these positrons may result from the decay of a new particle created in the heavy ion collision. Improvements in the equipment that produce ions at Argonne National Laboratory (ANL) are being implemented to investigate this phenomenon further.

- Knowledge of so-called "hot nuclear matter" aids our ability to understand collapsing stars as they consume all of their nuclear fuel. According to astrophysical calculations, nuclei should be compressible so they can bounce back from a gravitationally driven implosion, creating a shock wave that may lead to an exploding star (supernova). However, recent results from high-energy heavy ion collision experiments at the Lawrence Berkeley Laboratory's (LBL) BEVALAC indicated that nuclear matter is not very compressible. This result leads to a distinct scientific dilemma whose resolution is not clear.

- The weak nuclear force can be investigated by observing the interaction between a neutrino and an electron. The neutrino is a tiny uncharged particle, far smaller than a neutron, which appears in the process that

produces beta rays. The neutrino is also very difficult to detect because of its lack of electric charge and to-date unmeasurable mass. At the Los Alamos Meson Physics Facility (LAMPF) over 30 billion neutrinos passed through detection apparatus in order to produce and detect only 51 scattering events. These measurements took six months. However, these results were consistent with the standard model of elementary particles, thus clarifying our knowledge of the weak nuclear force.

The FY 1987 Nuclear Physics experimental program will continue to build on the above accomplishments. The program will continue to emphasize the fundamental properties of nuclear matter; the experimental investigation of the behavior of quarks inside nuclei, and the way in which quarks determine the characteristics of nuclei. In nuclear theory, emphasis will be on understanding the limitations of the present quantum chromodynamics theories of the nuclear force, on improving these theories, and on understanding the ways different quark configurations are revealed in experimental investigations.

FY 1987 NUCLEAR PHYSICS BUDGET REQUEST

The FY 1987 budget request for the Nuclear Physics program is $224.2 million. Of that amount, $174.9 million is for Operating Expenses, $16.0 million is for Capital Equipment, and $33.3 million is for construction (Table 4).

Before I comment in more detail on the Nuclear Physics request, I would like to focus on the highest priority Nuclear Physics construction project. The FY 1987 request includes $25 million for initiation of

Table 4
Nuclear Physics
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses				
Medium Energy Nuclear Physics	$ 73.9	$ 76.5	$ 73.1	$ 85.0
Heavy Ion Nuclear Physics	49.0	52.4	50.2	63.7
Low Energy Nuclear Physics	13.3	12.6	12.1	15.7
Nuclear Theory	9.3	9.4	9.0	10.5
Subtotal	$145.5	$150.9	$144.4	$174.9
Capital Equipment	12.7	14.0	13.4	16.0
Construction	23.3	7.0	6.7	33.3
Total Nuclear Physics	$181.5	$171.9	$164.5	$224.2

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construction of the Continuous Electron Beam Accelerator Facility (CEBAF) plus $6.25 million in operating expense funds for supporting research and development. CEBAF, which will be a new, single-purpose facility for basic nuclear research, has the highest priority for new construction in basic nuclear research in the United States. Its combination of continuous beam, high current, and high energy will be unique in the world and will be important to maintain America's position of worldwide leadership in basic nuclear research. It will be operated as a user facility serving a nationwide and international community of nuclear scientists. The central instrument of CEBAF will be an electron accelerator with an energy range of 0.5 to 4.0 billion electron volts (GeV). The construction project includes an initial complement of experimental equipment and support facilities necessary to perform scientific investigations using CEBAF's high quality electron beams.

When CEBAF's energy is at its highest, the electron beam from the accelerator will probe aspects of the underlying quark structures of the protons or neutrons, thus providing a direct test of the newly developed picture of nuclear matter. When CEBAF's energy is at its lowest values, the electron beam interacts as if it sees the traditional protons and neutrons. Thus this facility provides access to the transition region between the old and new descriptions of nuclear matter.

Upon completion of construction, scientists will be able to investigate the ways in which the quarks contained in neutrons and protons influence the makeup and behavior of nuclei. They will also be able to determine how quarks interact while imbedded in nuclear matter, and to test quantum chromodynamics as the fundamental theory of the strong nuclear force.

As is the case with High Energy Physics, the Nuclear Physics program depends upon the operation of large and complicated accelerator facilities to provide the variety of projectile beams and energies required to conduct the nuclear research program. Of the Operating Expenses request of $174.9 million, $93.3 million is needed for operation of these facilities, with the balance for experiments and theoretical research at the accelerator facilities and universities. In FY 1986, the national facilities are expected to achieve an overall utilization rate of 55 percent. These national facilities are: the Clinton P. Anderson Meson Physics Facility at Los Alamos National Laboratory (LANL); the Bates Linear Accelerator Center at MIT; the SuperHILAC/Bevalac at Lawrence Berkeley Laboratory (LBL); the Argonne Tandem/Linac Accelerator System (ATLAS); the Holifield Heavy Ion Research Facility at Oak Ridge National Laboratory (ORNL); the 88-inch Cyclotron at LBL; and the Double MP Tandem/AGS facility at Brookhaven National Laboratory (BNL). To complement these national facilities, the Nuclear Physics program also supports on-campus accelerators at Yale, Duke, the University of Washington, and Texas A&M, each of which is being upgraded to maintain its effectiveness.

The FY 1987 Nuclear Physics Operating Expenses request also includes funds for initial heavy ion nuclear research and 1000 hours of accelerator operations at the Alternating Gradient Synchrotron (AGS) at BNL. Upon completion in FY 1986, the Tandem/AGS Heavy Ion Transfer Line will provide heavy ion beams to the AGS for acceleration to the energies of 14 GeV per mass unit. This unique capability offers the possibility that scientists may be able to create exotic new conditions of nuclear matter at high temperatures and densities.

The Capital Equipment request of $16.0 million would provide for particle detection systems, data acquisition and analysis systems, and instrumentation to improve the performance of Nuclear Physics accelerators. These funds are essential for the effective operation and utilization of the national accelerator facilities by the Nuclear Physics program.

Of the total Capital Equipment request, $14.8 million is required for projects at BNL, LBL, ORNL, ANL, LAMPF, Bates Linear Accelerator Center, Oak Ridge Associated Universities, and Duke University. The Nuclear Physics program has landlord responsibility for providing the general purpose equipment at LBL, and $1.2 million is requested for that purpose.

The FY 1987 Construction request of $33.3 million (Table 5) includes $25 million for the Continuous Electron Beam Accelerator Facility. It also includes $4.3 million for Accelerator Improvements and Modifications Projects and $4.0 million for General Plant Projects ($4.0 million). These latter projects are needed to maintain the scientific effectiveness, reliability, and efficiency of Nuclear Physics facilities.

GENERAL SCIENCE PROGRAM DIRECTION

The FY 1987 budget request for General Science Program Direction is $2.5 million. These funds are required to provide for the salaries, benefits, travel and other expenses associated with 39 full-time equivalents in the Office of the Associate Director for High Energy and Nuclear Physics and associated support staff required to administer these programs.

Now let me turn to the Basic Energy Sciences program.

Table 5
Nuclear Physics
Budget Authority
($ in millions)

	FY 1987 Request	TEC	Completion Date
Construction			
Continuous Electron Beam Accelerator Facility (87-R-203)	$ 25.0	$236.0	FY 1992
Accelerator Improvements and Modifications Projects (87-R-201)	4.3	4.3	FY 1989
General Plant Projects (87-R-202)	4.0	4.0	FY 1989
Total Construction	$33.3		

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BASIC ENERGY SCIENCES

The goal of the Basic Energy Sciences (BES) program is to uncover the basic scientific and engineering knowledge that can be used by the Government and the private sector to develop new concepts, products, materials and processes. Although the principal focus of the BES program is aimed at underpinning the Department's energy goals, a number of other important national goals are also supported. U.S. leadership in science and technology, stimulation of economic growth, national security and the training of tomorrow's scientists are additional goals to which BES contributes as a result of the support of basic research.

The BES program annually supports approximately 1200 individual research projects in the physical, biological and mathematical sciences. These projects are selected on the basis of scientific excellence, relevance to BES' support of DOE long-term goals, and their contribution toward a coordinated research program. This research is carried out largely by scientists at universities and national laboratories across the country.

Important results of supporting university researchers are the knowledge and technology transfer that occur when graduate students enter the private sector after completing their studies. In addition to research at universities and DOE laboratories, to a lesser extent, BES also supports research in industry and maintains contact there through a variety of mechanisms. These include participation in workshops, peer review panels, and the use by industry of the specialized research facilities supported by BES.

BES research covers the following seven areas: materials sciences; chemical sciences; nuclear sciences; mathematical sciences; engineering and geosciences; biological sciences; and advanced energy projects. The ultimate impact of the research results from over 1200 projects will be far reaching. While contributions from basic research cannot always be identified immediately or directly, the knowledge that flows from this research forms the current foundation on which new ideas and concepts grow in each of these areas.

The following paragraphs summarize a few of the many BES research accomplishments for the year. They provide some idea of the wide range of research carried out and of the potential impact of research results.

- o In the Materials Sciences subprogram, very promising research is being supported on superconducting materials--materials that, at low temperatures, conduct electricity (electrons) without any loss of electrical energy. Materials that carry electrical current are important in numerous applications involving the transmission of electrons, including cables that carry electrical power, wires that conduct current in motors and generators, and electrical conductors in devices that produce magnetic fields, such as those used for medical diagnosis, in advanced electronic equipment or for many industrial applications such as electromagnets. Most of the materials used for these applications currently are metals such as copper.

  During the past year, using principles established in earlier work, a new metal-organic compound with improved superconducting properties was designed and synthesized. The achievement was the result of a

collaborative effort among researchers at Argonne National Laboratory, Sandia National Laboratories, and Strem Chemical Company. Work will continue on this effort to develop new superconducting synthetic organic-metals with potential for use in electronic systems.

o In the Chemical Sciences subprogram, promising research is being conducted in solar photochemical energy conversion, that is, photosynthesis. Sunlight is used by plants to convert carbon dioxide from the air and water into food and combustible materials. Chemical scientists are working to understand this process which is at the same time the most common and the most complex of the processes which occur in the environment around us.

Major advances have recently been made in understanding how sunlight makes the initial separation of electrical charges occur in the plant's "reaction center." It is this charge separation that initiates the chemical reactions of photosynthesis. By learning how to control the length of time the charges are kept apart, scientists hope to open up a new area of using photosynthesis-like processes to carry out useful chemical reactions. Recently researchers at Argonne National Laboratory set a new record for maintaining charge separation, 2.4 millionths of a second! Though exceedingly brief by human standards, this is a long time by molecular standards. A better understanding of the photosynthesis offers the potential for improvements and new developments in solar-related technology.

- In October 1984, Princeton University scientists announced the first demonstration of a laboratory-size x-ray laser. More recently, in work supported by the Advanced Energy Projects subprogram, the next big step was achieved -- a successful use of mirrors to enhance the x-ray radiation. There are many important uses for high-intensity, laser-produced x-rays in medicine, physics, biology, and technology. In medicine, the finely focused x-ray laser would allow better pin-pointing in the use of CAT scanners and other devices aimed at specific body organs, cancerous tissues or tumors. Physicists could make extensive use of x-ray lasers to measure temperature, impurity densities, and other important factors in fusion experiments. X-ray lasers could substantially improve structural analysis of some materials, and x-ray microscopes would be even sharper than present day electron-beam systems.

- The availability of high speed computers has made numerical solutions extremely valuable in dealing with complex phenomena. For instance, physicists and engineers are interested in the behavior of gases over a wide range of temperatures and pressures including behavior under drastically changing conditions. Recently, with funding from the Applied Mathematical Sciences subprogram, a new class of numerical methods designed to resolve such problems was developed. Previous computational results were not adequate because of the constraints of computer technology available at the time. These new results are better because they were obtained with updated numerical methods on a modern supercomputer (Cray-1). These computational tools are an effective alternative to laboratory testing and are being incorporated into large applications programs currently in use at DOE laboratories.

- Successful petroleum exploration is becoming more and more dependent on obtaining and evaluating extensive data to assess an oil field's potential. Two expensive methods, drilling and seismic studies, are the most common means of data gathering. New techniques for data interpretation that demand less data input or lead to more reliable assessment could significantly decrease oil prospecting and production costs. With funding from the Engineering and Geosciences subprogram, studies of related chemical and physical movement phenomena that occur under particular geochemical conditions have led to a novel computer program that models what minerals are present in a basin and the processes over time that have led to their current locations. From the geochemical history at a given location, estimates are made regarding the previous conditions in the basin and its suitability for oil production. The incorporation of this practical modeling technique into petroleum companies' exploration programs could result in a significantly enhanced discovery success rate.

- The role of light in plants is not limited to photosynthesis; light also controls many aspects of plant growth and development. Many of these nonphotosynthesis light effects have been shown to be influenced, if not controlled, by a substance called phytochrome. Based on recent studies supported by the Biological Energy Research subprogram, there appears to be a different protein associated with the phytochrome found in plants grown in light in comparison to that in plants grown without light. The protein from light-grown plants is being isolated and chemically studied to learn more about the chemical mechanisms that are involved in the

light-induced regulation of plant growth and development, factors critical to potential increases in plant productivity and ultimately enhancement of available renewable resources.

BASIC ENERGY SCIENCES FACILITIES

The kind of research progress depicted by the above examples is made possible, in part, by the large state-of-the-art facilities that are supported by the BES program. These facilities are not only an integral part of the Basic Energy Sciences program, but they also serve the general scientific community. Industry, university, and Government researchers have access to these facilities for promising research projects. These facilities are available at no cost to the user if the project is of high technical merit, falls within an area of programmatic interest to BES, cannot be carried out without access to the facility and is not proprietary.

If the research requires the use of the facility but is of a proprietary nature, a user fee is charged. This combination of laboratory, university and industry researchers working side by side is extremely beneficial. The Government gains because researchers supported by our program interact with their counterparts in the private sector and have access to the unique instrumentation and equipment that are provided at no cost to the Department by these counterparts. Both industry and the university communities gain by having access to some of the most advanced facilities in the world.

Several state-of-the-art facilities are in operation. Each promises to open whole new areas of research opportunities. These facilities include: the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory; the Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory; the

1.5 million electron volt High Voltage Electron Microscope and the Atomic Resolution Microscope (ARM) located at Lawrence Berkeley Laboratory's National Center for Electron Microscopy; and the Combustion Research Facility (CRF) at Sandia Livermore. As an example of the type of U.S. industrial research possible at one of the national user facilities, I would like to briefly discuss the research at NSLS.

There has been a very enthusiastic response to the NSLS from industrial scientists performing experiments on the x-ray and vacuum ultraviolet (VUV) storage rings. The industries presently involved with the NSLS represent the chemical, petroleum and communications industries among others. They include Allied Corporation, Ashland Oil, AT&T Bell Labs, DuPont, EXXON, General Electric, Gulf, IBM, Mobil, Stouffer Chemical, Union Carbide, Universal Oil Products, and Xerox. These industries are interested in a wide variety of research that they expect may ultimately lead to significant technological innovation. The primary areas of investigation include microelectronics, catalysis and the structure of materials.

In the area of microelectronics IBM scientists are working to fabricate an extremely small experimental working integrated circuit. Features as small as 0.25 micron (one one hundred thousandth of an inch) have been reproduced. If the IBM effort proves the technical feasibility of using synchrotron radiation for microcircuit reproduction, there could be a greatly expanded use of synchrotron radiation in this country, with storage rings becoming an integral part of semiconductor factories. Indeed, efforts have begun in Germany and Japan to develop compact superconducting storage rings for the semiconductor industry. Recently, a workshop at the NSLS was held to

consider how a similar effort might be undertaken in the U.S. and what would be the roles of private industry and of the Federal Government (through the expertise and the facilities of the national laboratories).

A number of the companies mentioned above have a common interest in studying catalytic reactions in the hope of developing more efficient catalysts. By using the high-intensity synchrotron radiation available from the NSLS, it will be possible to complete x-ray absorption and diffraction studies of catalysts during active operating conditions (elevated temperature and pressures) while the surfaces still remain active. These studies should help determine the structures and orientations of complicated organic molecules during catalysis. EXXON scientists are also using small angle x-ray scattering to study the pore structures in rock since this relates to the rate of flow of oil through various geological formations. The same technique is also being used to characterize the aggregation of organic macromolecules in petroleum crude since this has a direct bearing on the refining process.

There also have been a number of experiments carried out at NSLS by university and Government laboratory scientists, as well as by industrial lab researchers, in the area of structure of materials. Scientists have carried out a wide range of topography and x-ray diffraction, absorption, and scattering experiments on technologically important metal alloys and semiconductors to study defects and microstructures. And researchers from Du Pont have recently carried out a study of corrosion inhibitors in aqueous solutions for use in protecting aluminum and its alloys. The success of these experiments is leading to expanded use of NSLS by materials scientists from all sectors of the scientific community.

A list of the major BES user facilities is contained in Table 6.

FY 1987 BASIC ENERGY SCIENCES BUDGET REQUEST

The FY 1987 budget request for the BES program is $441.4 million, which consists of $380.1 million in Operating Expenses, $31.8 million in Capital Equipment and $29.5 million in Construction funds (Table 7). This request supports the core program for each of the research areas, with modest increases in each of the subprogram areas for major user facility operations and for enhancements to selected promising research areas. The requested increase for facilities will cover increased costs related to power, fuel, and essential operating personnel, as well as safeguards and safety requirements.

Of the total FY 1987 Operating Expenses request of $380.1 million, approximately 30% will be spent to operate and carry out research at the major BES facilities. As I noted earlier, these facilities are used not only by the Department, but also by other Federal agencies, by industry and by university researchers. They represent an investment in the Nation's long-term research and technological future. The budget request will ensure continued operation and access to these facilities in FY 1987. In addition to maintaining existing facilities, the FY 1987 budget also begins the necessary first step toward meeting the Nation's need for the next generation of advanced facilities.

In this context, the highest priority BES-related facilities proposed are the 1-2 GeV Synchrotron Radiation Source (LBL) for which construction funds are requested, as well as the 6 GeV Synchrotron Radiation Source (ANL) and an Advanced Steady State Reactor (ORNL). The FY 1987 Operating Expenses

Table 6
Basic Energy Sciences Facilities

High Flux Beam Reactor (HFBR) - Brookhaven National Laboratory

National Synchrotron Light Source (NSLS) - Brookhaven National Laboratory

Intense Pulsed Neutron Source (IPNS) - Argonne National Laboratory

High Voltage Electron Microscope-Tandem Facility - Argonne National Laboratory

Oak Ridge Electron Linear Accelerator (ORELA) - Oak Ridge National Laboratory

High Flux Isotope Reactor (HFIR) - Oak Ridge National Laboratory

Combustion Research Facility (CRF) - Sandia National Laboratories, Livermore

National Center for Electron Microscopy - Lawrence Berkeley Laboratory

Stanford Synchrotron Radiation Laboratory (SSRL) - Stanford University

Los Alamos Neutron Scattering Center (LANSCE) - Los Alamos National Laboratory

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Table 7
Basic Energy Sciences
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses				
Materials Sciences	$132.2	$139.5	$134.3	$156.9
Chemical Sciences	78.6	81.2	78.1	86.4
Nuclear Sciences	39.6	43.1	41.4	46.9
Applied Mathematical Sciences	34.5	39.4	37.9	32.8
Engineering and Geosciences	26.1	26.6	25.6	29.4
Advanced Energy Projects	10.1	7.6	7.3	9.0
Biological Energy Research	12.4	12.4	12.0	14.6
Program Direction	3.8	3.6	3.5	4.1
Subtotal	$337.3	$353.4	$340.1	$380.1
Capital Equipment	31.1	27.3	26.2	31.8
Construction	42.4	70.1	67.5	29.5
Total Basic Energy Sciences	$410.8	$450.8	$433.8	$441.4

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request includes funds for continued R&D on the latter two facilities. The concept and need for these facilities have been reviewed and recommended by several committees, most notably and recently the National Research Council (NRC) study of Major Materials Facilities and the DOE Energy Research Advisory Board review of the NRC report.

The Capital Equipment request for FY 1987 is $31.8 million. The requested funding will assure that researchers involved in our program continue to have the modern, sophisticated equipment needed to conduct advanced research. This level of funding is necessary to meet ongoing research requirements, additional commitments associated with the new facilities and additional equipment for selected areas of promising research. Examples of equipment to be purchased include high resolution nuclear magnetic resonance equipment, a fluid chromatograph for use in analyzing chemical solutions, infrared spectrometers, chemical vapor deposition apparatus, and an x-ray microprobe analyzer.

Table 8 details the Construction request for FY 1987. Three of the projects are associated with the materials initiative which began in FY 1984. That activity currently consists of a Center for Advanced Materials (CAM) at LBL, improvements at the Stanford Synchrotron Radiation Laboratory and expanded activities at the BNL National Synchrotron Light Source. The economic health and national security of the U.S. require that we maintain a commanding lead in high technology. The ongoing advanced materials research activity is being organized to provide maximum benefit to the Nation. Industry is participating in the design of the research program to assure that it addresses America's high technology needs.

Table 8
Basic Energy Sciences
Construction Summary
Budget Authority
($ in millions)

	FY 1987 Request	TEC	Completion Date
Center for Advanced Materials (84-ER-112)	$ 10.5	40.2	FY 1988
Beam Lines and Support Area Construction, NSLS (84-ER-111)	2.6	19.4	FY 1987
Stanford Synchrotron Radiation Laboratory Enhancement (84-ER-113)	1.7	12.8	FY 1987
Kansas State University Ion Collision Physics Facility (85-ER-403)	1.2	$ 5.0	FY 1988
Neutron Scattering Experimental Halls, LANL (87-R-403)	5.0	17.5	FY 1989
General Plant Projects (87-R-400)	4.1	4.1	FY 1988
Accelerator Improvements and Modifications Projects (87-ER-401)	2.9	2.9	FY 1988
1-2 GeV Synchrotron Source (87-R-406)	1.5	1.5	AE and Long Lead Procurement
Total	$29.5		

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The CAM project consists of two buildings: a Surface Science and Catalysis Laboratory which will provide state-of-the-art instrumentation and facilities and the Advanced Materials Laboratory which will be devoted to interdisciplinary study of the synthesis and characterization of energy-related high technology and strategic materials. Both of these facilities will be based on strong programs that exist at the Lawrence Berkeley Laboratory. The FY 1987 budget includes $10.5 million for this project.

For the SSRL, the FY 1987 request is $1.7 million to complete the project. This funding will allow us to continue three principal items: the construction of two conventional beam lines and three special beam line facilities as well as the alteration of the electron storage ring. These improvements will ensure the usefulness of this facility for basic research for many years to come.

At NSLS, $2.6 million is requested in FY 1987. This funding completes the project and will meet the demands for a much higher level usage by providing additional experimental equipment and space. When fully instrumented, the NSLS facility will be able to accommodate 90 experiments simultaneously.

Another major project proposed for final funding in FY 1987 is the Kansas State University Ion Collision Physics Facility; $1.2 million is requested for this project. This facility, which is jointly funded by the University and DOE, will allow researchers to study the atomic physics of a range of ions unmatched in the world.

The budget also includes $5.0 million for continuing the Neutron Scattering Experimental Hall project at LANL, which was begun in FY 1986. As a result of this project, a significant enhancement in research space will be made available to take advantage of the unique (highest neutron-flux in the world) capability at this facility.

Construction funds are requested also for General Plant Projects and Accelerator Improvements and Modifications Projects. For these two construction items, the FY 1987 request is $4.1 million and $2.9 million, respectively.

The final project for which FY 1987 funding is requested is $1.5 million for A-E and long-lead procurement for the 1-2 GeV Synchrotron Source. Significant preconstruction R&D has been completed. This facility, as I mentioned earlier, is a state-of-the-art synchrotron source which is a necessary step in keeping the U.S. at the cutting edge of technology in the next century.

The budget request for Program Direction provides for personnel and other costs associated with continuation of 63 full-time equivalents.

MAGNETIC FUSION ENERGY

To assure our national long-term energy options, it is appropriate for the Federal government to sponsor R&D in those areas where the cost or duration of the program discourages private investment. The Magnetic Fusion program is a clear example of appropriate energy research for the Federal portfolio.

The goal of this program is to establish the scientific and technological base required for fusion energy. The program is making excellent technical progress toward this goal.

The long-term need and desirability for fusion energy continues to be strong. However, the program plan and the program budgets have been adjusted to reflect improvements in our near-term energy supply as well as the need to control Federal spending. During the mid-1970's the Magnetic Fusion Energy program responded to the then looming energy crisis, by laying out a plan that was dedicated to the goal of having a fusion energy reactor by the year 2000. A set of program activities was developed and a pace established to meet this goal. However, due to a relaxation in the energy crisis situation, there is now less urgency to develop an energy supply system based on the nuclear fusion principle. The desirability for such a system, however, remains strong.

Therefore, a revised Magnetic Fusion Program Plan was developed and put into place last year. This plan took into consideration the present economic conditions, the current energy situation and how it might change in the future, technical progress in fusion research, the ability to train scientists and engineers, and contributions to basic research in the fields of plasma physics, atomic physics and technology transfer. This plan has been accepted by both the Congress and the technical community.

The development of magnetic fusion could lead to economic energy sources that possess a secure fuel reserve, as well as acceptable environmental and safety features. The fuel, deuterium (and tritium from lithium), is readily

available at low cost, and its supply is essentially unlimited. Potential end use applications are electricity generation, the production of synthetic fuels, nuclear fuels, and high grade heat for industrial applications.

The schedule for completion of magnetic fusion development is directly related to the present technical, economic, and political uncertainties of energy supply. Knowledge of how to employ fusion power, its economic costs and its environmental effects should be available when major decisions must be made on the deployment of new energy systems. Based on the estimated timescales for the resolution of uncertainties affecting the acceptability of other energy sources, it follows that the scientific and technological base for fusion should be available by the turn of the century.

Fusion has a unique role in the process of determining our Nation's energy future. In principle, fusion energy has the flexibility to fit a variety of future energy scenarios. Fusion may provide improvements to the attractiveness of other energy sources as well as providing an attractive alternative to these sources.

Although magnetic fusion research and development is addressing a wide range of detailed scientific and technological problems, the remaining work that must be accomplished to reach the program goal can be summarized by defining four key issues.

The first of these issues concerns magnetic confinement systems. The particular type of magnetic geometry used can have a profound influence on the economics of a fusion device. Although significant progress continues to be made, it is not possible to design a fusion reactor at this time. Therefore, several potentially attractive confinement systems are being

investigated. While many of these have similar features, it is likely that the most desirable system will include features from several different confinement systems. In addition, history has shown that progress in all systems will be more rapid because of the cross-fertilization possible between related concepts.

The second key technical issue concerns the properties of burning plasmas. Understanding the properties of burning plasmas is required to complete the scientific base. Furthermore, since a burning plasma will require much of the technology required for a fusion reactor, it offers the additional benefit of advancing the technological position of the program goal.

The third key issue concerns materials for fusion systems. Since materials play a central role in determining the environmental characteristics of a fusion reactor, they are the key to realizing the benefits of fusion. Achievement of the program goal requires the development of new materials to enhance the economic and environmental potential of fusion.

The fourth key issue concerns nuclear technology of fusion systems. This issue requires advances in the basic engineering sciences, as well as the application of the results of basic fusion materials research. This issue will be completed only when integrated blankets are tested in a nuclear environment. A blanket is the structure surrounding the fusion plasma.

Our present strategy for addressing these issues is to take a complementary approach. This approach emphasizes development of the scientific and technological components or subsystems of the integrated fusion system to the maximum extent that is technically feasible. This approach is most appropriate for our program goal in the present circumstances. It allows

accommodation of budget stringency, as well as for progress to resolve the technical uncertainties that exist about the exact nature of a suitable fusion reactor. There appears to be no premium on early deployment of fusion in our present energy circumstances. Therefore, time is available to perfect the fusion energy source, which we expect to be a critical necessity in the long run. Finally, the utilization of the United States portion of the world's fusion development resources can be enhanced by this approach, since it provides the flexibility to collaborate internationally.

The essence of the program strategy is to maintain a broad domestic research and development program with emphasis on establishing the basic elements (components or subsystems) of the science and engineering technology required for fusion. Given the revised program goal, a great emphasis will be placed on creativity and innovation to enhance the economic and environmental attractiveness of fusion as an energy source, which will be assessed in comparison with other potential energy sources.

The focus on the practical energy goal of the program will be provided by fusion system studies. Technology transfer will be pursued by seeking industrial and utility participation in these system studies, as well as in appropriate research and development activities. To make best use of the United States' scientific strength in the area of fusion plasma research, a number of magnetic confinement systems, which offer promise of superior reactor performance, will be investigated. However, recognizing constraints on available resources, this investigation will emphasize increasing scientific understanding of the unique features of the most promising concepts, rather than attempting to develop each as a separate reactor

system. To achieve a complete scientific base, we intend to address the scientific issues of fusion in depth through the generation and study of high temperature plasmas in facilities of appropriate size and scope, including a burning plasma experiment. In the latter experiment, the lowest cost magnetic confinement system that can meet the scientific objective will be sought. This approach is intended to provide the broadest understanding at minimum cost and is most appropriate for the present stage of fusion development.

Over the last decade, a significant investment in equipment and facilities has been made and a core group of skilled scientists and engineers has been trained. With this investment in place, excellent and sustained progress is being made. We have reached a point now where there is general agreement that the remaining technical problems can be solved. The new generation of tokamaks has produced temperatures of one hundred million degrees and average energy confinement times of nine-tenths of a second. The experimental campaign to achieve energy breakeven conditions has just begun in the Tokamak Fusion Test Reactor (TFTR) at Princeton University. It appears that 1987 will mark the achievement of a goal sought for nearly 40 years. Actual breakeven using deuterium and tritium fuel is planned for FY 1989. The general scientific progress of the last decade has also advanced the performance and future prospect of several other magnetic confinement systems. Several toroidal systems have achieved a state of scientific maturity such that they appear capable of exceeding the power density necessary to be a competitive economic power system.

On the technology side, a reactor-scale tritium fueling system is operating at Los Alamos National Laboratory. The International Large Coil Project at Oak Ridge National Laboratory is beginning operation to demonstrate reactor-scale superconducting magnets. Radio-frequency heating modules at reactor power levels and pellet fueling systems have been developed and applied to our largest experiments. The feasibility of materials which are long lived in a fusion environment has been established for two classes of alloys. Initial work on the development of second generation low activation materials shows good promise.

While unresolved scientific and technological problems remain, the key achievements that were targeted by the program in the planning of the mid-1970's have been or are being realized. However, it is almost axiomatic that achievement of the technical goals of a ten-year program plan requires the revision of future program goals to fit new externalities.

FY 1987 MAGNETIC FUSION ENERGY BUDGET REQUEST

The FY 1987 budget request for Magnetic Fusion Energy is $333.0 million. The request includes $307.5 million for Operating Expenses, $17.3 million for Capital Equipment, and $8.2 million for Construction (Table 9).

Given this current technical status and the revised program strategy, the FY 1987 budget request was developed with two major factors in mind. The first is a need to maintain a balance between our domestic science and technology program and those abroad, in order to allow effective international collaboration to supplement our domestic activities. The second is the need to support those experimental investigations that are appropriate in order to maintain progress. Facilities that are large enough to explore high

Table 9
Magnetic Fusion Energy
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses	$369.6	$337.3	$324.5	$307.5
Capital Equipment	27.5	29.4	28.3	17.3
Construction	32.5	13.1	12.7	8.2
Total	$429.6	$379.8	$365.5	$333.0

temperature regimes of plasma physics are required, as well as a number of smaller facilities for investigating key problems or scientific issues that can be addressed at more modest plasma temperatures.

The FY 1987 budget request has been developed to take advantage of the technical position that already has been established in fusion research. It will allow a continuation of cost effective progress toward the development of fusion power as a future energy option and will position the program to support the President's Geneva initiative on international cooperation in this area.

The budget request for FY 1987 reflects a significant shift in the program balance. The near-term scientific and technological output of the program will be emphasized while continuing to pursue the long-range goal of developing fusion at a pace consistent with our national energy needs. The near-term program achievements also will continue to include the production of well trained scientists and engineers and contribution of advanced technology developments for industrial and defense applications.

The request of $333 million represents the level of resources required to maintain an effective program. In order to maintain progress at this level of funding, the program has been narrowed to pursue only toroidal confinement systems. In addition, we have identified the highest priority tasks, improved the cost effectiveness of facility operations, and increased the use of international collaboration. The program has been focused to address the four remaining key technical issues--namely, the development of magnetic confinement systems, understanding of scientific principles of a burning plasma, the development of materials for fusion applications, and

the development of fusion nuclear technology. The FY 1987 budget request of $333 million will maintain some effort in each of these four key technical issues. At this level the FY 1986 initiatives needed to implement the revised program plan continue while other program elements are delayed or deferred.

The Magnetic Fusion Energy budget is organized into five interrelated functional areas that form the basis of a unified and balanced effort to conduct the research and development necessary to define a practical fusion product. The Confinement Systems and the Applied Plasma Physics subprograms, working in conjunction, provide the physics base for the Magnetic Fusion Energy program. In the near-term, the achievement of plasmas with the characteristics required to produce fusion energy flow from the experiments conducted in the Confinement Systems subprogram, with its focus on toroidal confinement systems. The Applied Plasma Physics (APP) subprogram develops plasma physics theories and models to predict and explain the experimental and theoretical investigations of basic physics problems related to confinement concepts and develops diagnostic instruments for use by the Confinement Systems subprogram. This subprogram also conducts the first exploratory experiments on new magnetic confinement configurations.

Using information developed by these two subprograms, the Development and Technology subprogram develops components and systems for use in near- and mid-term fusion experiments, and long-term generic materials. This subprogram also performs conceptual design studies for fusion power reactor

concepts and next generation devices. These design studies identify component and system development needs that must be undertaken to prepare for the eventual application of fusion.

In carrying out the assignments of the physics and technology tasks, needs for major new facilities are identified from time to time. The Planning and Projects subprogram provides for construction of major new facilities and fabrication of auxiliary components for these facilities. Finally, the Program Direction subprogram includes the funding to cover salaries, benefits, travel, and related expenses of the Headquarters Office of Fusion Energy and associated support staff. The proposed budget levels for these areas are indicated in Table 10.

I would like to highlight some of the significant provisions of the FY 1987 budget request. In toroidal confinement systems, funds are provided to support the experimental operations of the Tokamak Fusion Test Reactor (TFTR) and the Princeton Beta Experiment (PBX) at the Princeton Plasma Physics Laboratory; the Doublet III-D (D-IIID) at General Atomic Technologies, Inc.; and the Advanced Toroidal Facility (ATF) at the Oak Ridge National Laboratory. The TFTR device will attempt to reach breakeven conditions and continue preparation for limited D-T operations in 1989. Doublet III-D, operating with a new vacuum vessel, will explore beta limits with shaped plasmas as part of the U.S./Japan cooperative program. In addition, procurement of long pulse ion sources for the device will be completed. Fabrication of the ATF and PBX-Upgrade will be completed and operations will begin to investigate advanced toroidal ideas. The Alcator C at the Massachusetts Institute of Technology and Princeton Large Torus

Table 10
Magnetic Fusion Energy
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses				
Confinement Systems				
Toroidal Confinement Systems	$151.4	$147.1	$141.5	$151.8
Mirror Confinement Systems	55.0	49.0	47.1	25.7
Applied Plasma Physics	78.9	72.4	69.7	70.7
Development and Technology	67.9	59.3	57.1	50.5
Planning and Projects	12.2	5.7	5.5	4.8
Program Direction	4.2	3.8	3.6	4.0
Subtotal	$369.6	$337.3	$324.5	$307.5
Capital Equipment	27.5	29.4	28.3	17.3
Construction				
Fusion Materials Irradiation Test Facility	3.0	0	0	0
Mirror Fusion Test Facility-B	20.1	4.0	3.9	0
General Plant Projects	9.4	9.1	8.8	8.2
Subtotal	32.5	13.1	12.7	8.2
Total	$429.6	$379.8	$365.5	$333.0

experiments will be completed and the devices shut down. Collaboration abroad, especially on European Tokamaks, will continue in order to gain valuable information while avoiding duplication.

Studies to explore expanded collaboration with the Soviets will begin support of the President's Geneva initiative on international cooperation in fusion.

In the Mirror Confinement System program, the Tandem Mirror Experiment (TMX-U) at Lawrence Livermore Laboratory, TARA at Massachusetts Institute of Technology, and Phaedrus at the University of Wisconsin will be completed and the devices will be shut down. The MFTF-B facility at LLNL will be put in standby condition after completion of the construction project in FY 1986. This decision was made recognizing that increased fiscal stringencies would not allow us to continue support of all experimental devices. Since the toroidal configuration is the most developed of all concepts, we have chosen to focus the experimental physics effort around the toroidal concept.

In FY 1987, Applied Plasma Physics will continue several important tasks begun in FY 1986 and will maintain a core base of research. Fabrication of upgraded reversed field pinch and compact toroid experiments will be continued to allow study of plasmas closer to fusion conditions in these attractive subclasses of the toroid confinement concept. Tests of several promising theoretical ideas for tokamak improvements also will be continued in small-scale experiments. In addition, more realistic models of fusion plasma behavior will be developed and tested, aided by the installation of the Cray 2 computer, the first of this new generation, at the National Magnetic Fusion Computer Center.

In the Development and Technology area, program effort will be focused on the most critical technology issues. Experiments on the International Superconducting Magnet Test Facility at the Oak Ridge National Laboratory will be completed. Design of ion cyclotron radiofrequency heating components is to be emphasized. Nuclear technology effort will include nuclear analysis methods, blankets, and tritium processing and control systems. In the materials program, effort on plasma materials and interactions and reduced activation and fundamental studies on neutron effects on alloys will continue with transition from the Oak Ridge Reactor to the High Flux Isotope Reactor. Design of an ignited, burning plasma experiment will continue.

In Planning and Projects, funds are provided to support the program's landlord reponsibilities at ORNL for GPP, GPE, and inventories, as well as the legislated requirements for the Small Business Innovation Research program.

The budget request for Program Direction provides for personnel and other costs associated with continuation of 62 full-time equivalents.

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

The Biological and Environmental Research (BER) program has two main goals: (1) to develop the knowledge base and scientific principles necessary to identify, understand and anticipate the long-term health and environmental consequences of energy use and development; and (2) to address major scientific problems in medicine and biology using the Department's unique

scientific and technological capabilities. The FY 1987 budget request will support high quality fundamental and applied research aimed at achieving these goals.

The principal strategy for meeting the first goal has been the development of a long-term research program that is comprehensive and multidisciplinary, and that provides both quantitative measurement of health and environmental processes and an understanding of how those processes operate. In keeping with the Department's mission this long-range, quantitative research will contribute to our ability to assess or predict the effects of energy strategies before they are adopted. This research contributes to the health of the Nation by providing the ability to avoid unacceptable impacts before rather than after they occur; it strengthens the economy by giving us the means to avert major economic stress associated with abrupt discontinuities in energy programs; and it allows us to optimize approaches to mitigating past mistakes. In short, the predictive principles provide the basis for rational planning and allocation of resources, and for minimizing adverse health and environmental impacts on future generations as well as on our own.

The comprehensive and multidisciplinary nature of the BER program is unique to the Nation, and arises as a natural consequence of the mission and capabilities of the Department of Energy. Predicting the health impacts of current or anticipated energy strategies requires an understanding of the health effects of the products of these strategies. To predict health effects, we must first understand the physics and chemistry of the movement and transformation of energy byproducts in terrestrial, marine and atmospheric environments. A comprehensive approach to the problem requires

the type of interdisciplinary strength and coordinated effort for which DOE's national laboratories are well known. These strengths are complemented by extraordinary field-study capabilities offered by the National Environmental Research Parks.

Because of the unusual characteristics of the BER program and the unique strengths which the Department can bring to bear on major life science problems, the program has spawned scientific and technological discoveries whose implications have far exceeded original goals. The wide-ranging implications of these accomplishments can be conveyed by a few brief examples.

Health effects research, aimed at understanding the mechanisms by which radiation interacts with, and damages, biological molecules led to the discovery of enzymes that repair damaged genes. Subsequent research has provided major insights into the genetic determinants of susceptibility and resistance to disease in general and, in particular, it has led to the discovery that certain types of cancer are strongly associated with repair enzyme deficiencies. One of the important BER program goals is to develop enough information about these enzymes so that they can be synthesized in the laboratory.

Similarly, research in atmospheric physics and chemistry, which began in the early 1950's in response to a need for understanding the movement of radionuclides through the atmosphere, has turned out to be central to approaching problems such as acid rain, and to understanding the causes and effects of changes in the atmospheric concentration of carbon dioxide and other "greenhouse molecules". Also the use of radiotracers in ecology,

stemming initially from concern over the fate and transport of fission isotopes in the environment, provided the concepts, tools, and resources to move ecology from a descriptive to a quantitative science. This resulted in a better understanding of the carbon cycle in the photosynthesis of plants, and laid the groundwork for new genetic engineering techniques.

Finally, in the area of measurement science, the flow cytometer, or "cell sorter", was originally developed to separate radiation damaged cells from normal cells. Today it is routinely used for performing complete blood counts, for detecting cancer and monitoring its treatment, and for detecting genetic abnormalities. More recent improvements have permitted scientists to obtain large purified quantities of each of the human chromosomes. The availability of this chromosome "library" is expected to have a major impact on the field of human genetics. Since flow cytometry is now a standard analytical technique in cell biology, its full impact is difficult to summarize, but many scientists consider it to be perhaps the single most important analytical advance in the history of cell biology.

The scientific and economic implications of these contributions and many others like them have been analyzed and documented recently. A publication describing these implications will be available for distribution in 1987. Our best estimates indicate that, on the basis of economic impact alone, the public's investment in the BER program and the programs that preceded it has been returned manyfold.

The second goal of the BER program, to address major scientific problems in medicine and biology using the Department's unique scientific and technological capabilities, had its origin in the 1947 mandate from Congress

to utilize advances in nuclear science for the treatment of human disease. At the time the mandate was written, even the most farsighted scientists and legislators would have had difficulty predicting the enormous contributions that the large multiuser facilities and their associated intellectual and advanced technological capabilities could bring to a wide range of problems, not just in medicine, but in basic biology as well.

Historically, the focus of the second BER mission area has been nuclear medicine -- the development and application of non-invasive imaging techniques, the production of isotopes for the study of metabolic and other kinetic processes, and the production of radiopharmaceuticals and radiation beams for the treatment of cancer and other diseases. These advances have cured or alleviated the sufferings of tens of millions of people throughout the world, and have spawned industries with markets valued at hundreds of millions of dollars per year. More recently, another non-invasive, non-nuclear imaging technique has been developed. This method, called magnetoencephalography, measures changes in magnetic fields generated by the activity of brain cells, and offers great promise for major progress in our understanding of neurological processes.

FY 1987 BIOLOGICAL AND ENVIRONMENTAL RESEARCH BUDGET REQUEST

The FY 1987 budget request for the BER program is $196.6 million. Within this request, $184.6 million is for Operating Expenses; $8.5 million is for Capital Equipment, and $3.5 million is for Construction (Table 11). Funding by research area is shown in Table 12.

Table 11
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses	$177.9	$176.0	$169.4	$184.6
Capital Equipment	7.1	7.8	7.4	8.5
Construction	2.7	3.2	3.1	3.5
Total	$187.7	$187.0	$179.9	$196.6

Table 12
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Late Effects on Health & Environment of Energy Development and Use				
Source and Dose Determination	$ 15.6	$ 15.3	$ 14.8	$ 16.6
Environmental Processes & Effects	32.4	31.1	29.9	32.9
Health Effects	63.4	59.9	57.7	65.9
General Life Sciences	28.5	29.1	28.0	29.9
Nuclear Medicine	21.3	24.2	23.3	22.1
Carbon Dioxide Research	13.1	13.1	12.6	13.6
Program Direction	3.5	3.3	3.1	3.6
Facility Operations	9.9	11.0	10.5	12.0
Total	$187.7	$187.0	$179.9	$196.6

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In order to meet its first mission goal, the BER program supports four major research areas: Source and Dose Determination; Environmental Processes and Effects; Health Effects; and General Life Sciences.

The Source and Dose Determination research program, with an FY 1987 Operating Expenses request of $16.6 million, develops the advanced instrumentation required to carry out the broad scope of the health and environmental effects research program. This advanced instrumentation provides the capability to determine precisely the type and quantity of material responsible for an observed effect. For example, the development of a new technique called remote fiber fluorimetry permits long distance measurement of the concentrations of toxic chemicals that are in hostile or otherwise inaccessible environments. This particular method is expected to be applicable to problems ranging from in vivo measurements of toxic chemicals to assessments of ground water contamination. Another method under development, fluorescence line narrowing spectroscopy (FLNS), can be used to determine whether cancer causing chemicals have become attached to a person's genes. The method is so sensitive that it can locate one affected gene in one hundred thousand, and it can distinguish cancer-producing forms of a molecule, from very closely related non-cancer causing forms. Further developments in this and similar methodologies will permit the identification of individuals who are at risk from exposure to carcinogenic substances well before the occurrence of clinical symptoms. Continued developments in measurement science are expected to yield methods that permit measurements of previously undetectable concentrations of harmful molecules, or of molecular "markers" signalling disease risk.

The Environmental Processes and Effects research area, with an FY 1987 budget request of $32.9 million in Operating Expenses, focuses on the pathways and mechanisms by which energy-related substances move through the environment, and on the ways that the environment itself may be affected by such substances. The program encompasses certain areas of atmospheric and oceanographic sciences, and terrestrial ecology.

The main atmospheric research programs are PRECP (Processing of Emissions by Clouds and Precipitation) and ASCOT (Atmospheric Studies in Complex Terrain). The goal of the first program is to develop a quantitative understanding of the physical and chemical processes responsible for incorporating and transforming ("processing") atmospheric pollutants into clouds and storms, and for removing them through precipitation. The PRECP program has completed three large field experiments exploring these factors in typical storm types. The information gathered from surface and aircraft measurements in these storms, together with laboratory simulations and diagnostic modeling, has validated hypotheses which are central to national concerns such as the understanding and control of "acid rain".

ASCOT aims at improving the fundamental knowledge of the processes responsible for the dispersion of atmospheric pollutants over complex (e.g., mountainous) terrain. In this activity, three-dimensional models of the turbulent flows over western mountain-valley systems, have been tested in seven field campaigns in four states. Along with other models developed in this program, they are directly applicable to emergency response planning and other Departmental concerns.

Research conducted in the oceanographic program on cycling and movement of energy materials off our coasts is providing crucial information for decisions on ocean disposal of energy and weapons related wastes. Since substances move from disposal sites to distant locations, knowledge of their migration patterns and rates of movement are crucial to making informed choices for disposal sites.

Marine research is carried out in three regional interdisciplinary programs. In the Northeast and Southeast regional programs, research is conducted to understand the characteristics and movement of living and non-living materials across the continental shelf and how they change as they move with ocean currents. Recently completed research suggests that most of the shelf material from the New York area is transported down the coast and moves off the shelf in the Cape Hatteras region to become entrained in the Gulf Stream. Surprisingly, our research indicates that in the autumn, coastal material from the Southeast moves up the coast from Georgia to North Carolina and also exists in the area of Cape Hatteras. Unravelling the dynamics of these phenomena in the second phase of this program will be important for determining the fate of these water masses and their contents in the ocean.

In the terrestrial system, prediction of the distribution and fate of energy-related materials such as radionuclides, trace elements, and organic compounds requires an understanding of the processes that control and affect the transport of chemicals in the subsurface environment. A number of new techniques and methods are being developed which will enable us to predict the movement of materials in ground water and their potential infiltration

into aquifers used to provide water for human consumption. This information will enable us to establish a rational, scientifically based set of priorities for mitigation of identified problems and siting of facilities.

Energy production and development can affect water use and produce varying degrees of landscape disturbance. Prediction and mitigation of these impacts can be successful only if basic processes affecting ecosystem functioning are well understood. Past research conducted under this program has described the sulfur cycle in forested ecosystems and is now providing crucial information on acid rain. Information on carbon cycling developed with support of this program is now a central part of the evaluation of CO_2 buildup.

Organisms vary in their capacities for tolerating stress caused by low levels of contaminants. Research has shown that in response to heavy metal contaminants, plants and animals synthesize specific proteins called metallothioneins which bind metals in the organism, thus decreasing the metal's mobility and effects on that organism. Companion studies are investigating the effects of heavy metals on the synthesis of immune proteins which mitigate disease processes. The results of these studies are being used to predict the ecological effects of energy-related contaminants on animal and plant species.

The FY 1987 Operating Expenses request for the Health Effects research program is $65.9 million. The general goal of the program is to develop the knowledge base needed to assess and predict the health effects of national energy options. Research ranges from detailed molecular studies designed to explain the workings of genes and proteins, to studies on laboratory animals.

The discovery that DNA damaged by radiation and chemicals is repaired by special enzymes was a landmark achievement which created a new subdiscipline called molecular epidemiology. This area, which will receive high priority, includes projects aimed at identifying, studying and synthesizing the genes that control and repair enzymes; and the identification of molecular markers for susceptibility and resistance to chemical and radiation damage. Studies will also be made to identify populations that may be especially susceptible to energy byproducts. Research on cancer-causing genes (oncogenes) that are activated by radiation and other energy-related materials will be expanded.

The research on molecular mechanisms and indicators of radiation damage will be coordinated with long-term animal studies on the correlation of various tumor types with well defined doses of irradiation and chemicals. Animal studies, which have been in progress for many years, provide the Department with an unusually large and quantitative source of data, which can be used to correlate molecular changes with clinical disease characteristics. This information is central to the problem of understanding tumor progression and finding molecular changes that can be used to diagnose disease years before clinical symptoms appear.

The majority of exposures of people to hazardous material are not to a single substance, but to complex mixtures of chemicals, and perhaps even to radiation and chemicals together. Studies of complex mixtures show that their health effects cannot always be predicted by adding the effects of isolated components. To understand this problem, a complex mixture program has been initiated to develop predictive principles related to potential toxic and mutation-causing effects.

Recent information indicates unexpectedly high levels of radon gas and its daughter products in some residential structures. An assessment of the associated health risks requires the entire spectrum of activities sponsored by the BER program. In particular, a complete assessment will not only require the development and testing of models of radon transport through the environment, but also carefully controlled epidemiological studies and fundamental studies of the mechanisms by which radon produces injury.

The epidemiologic research program includes investigations of human populations with occupational or environmental exposure to energy-related pollutants. DOE-supported radioepidemiologic studies are performed independently by scientists at universities and national laboratories, rather than by Federal employees. Among the major populations which have been studied are DOE and DOE contractor workers, Japanese atomic-bomb survivors, nuclear shipyard workers, and New Mexico uranium miners. These population studies will be supplemented by studies of lung cancer cases in communities located near DOE facilities. They will greatly refine our confidence in low-level radiation risk estimates which have been developed through extrapolation from populations exposed at high doses and dose rates.

The epidemiology program aims at uncovering possible effects on the health of an exposed individual. We also need to know whether effects are present that go unnoticed in the exposed person, but are instead transmitted to his or her progeny. This problem bears directly on the question of whether decisions made today will effect the disease burden transmitted to future

generations. Work in progress is focused on the development of new molecular techniques for studying the heritability of certain types of molecular, chromosomal and gene damage.

A project of central importance to both components of the BER mission involves the effort to determine the locations of genes on chromosomes (i.e., to construct a genetic map), and to decode or "sequence" the messages contained in those genes. Information of this type has been fundamental to the growth of biotechnology, as evidenced in such accomplishments as the large-scale production of insulin and of growth and other important hormones. Mapping and sequencing studies also bear directly on questions related to the heritability of mutations and the genetic predisposition to chemically and radiation induced diseases.

Research in General Life Sciences, for which $29.9 million in Operating Expenses is requested in FY 1987, provides the fundamental basis for the entire BER program. This research extends our base of biological information and develops concepts to improve our understanding of the health effects of various energy options. The program includes research on the structure and function of genes, the arrangement of genes on chromosomes, and the effect of gene location on their regulation and expression. This information is important since many debilitating diseases are the result of faulty gene regulation or expression.

The second major goal of the BER program is the use of the Department's unique scientific and technological capabilities to address major problems in medicine and biology. Use of the intense neutron beams produced by nuclear reactors and accelerators, and the synchrotron light produced by

electron storage rings, will permit information on the structure of proteins, nucleic acids and carbohydrates to be obtained faster and under more realistic conditions than was previously possible. These experimental capabilities, the Department's powerful computer network, and its unique breadth and depth in the mathematical sciences, will lead to new, rapid approaches to determining and predicting molecular structure. Progress in this area will have a major impact on the future of biotechnology including drug and vaccine design.

The budget request for the FY 1987 Nuclear Medicine Applications program is $22.1 million. Its objective is to continue to develop new nuclear medicine procedures through the production of new radionuclides, the radiolabeling of new biologically active agents, and advancements in high resolution instrumentation. Efforts to develop other medical applications using reactors, accelerators and other related nuclear technologies for the treatment of cancer will be maintained.

The new short-lived, radionuclide-labeled radiopharmaceuticals are proving to be useful in studies of the metabolic functions of the brain and heart. Major advances have been made to date in quantitating physiology and abnormal physiology in the human brain and heart utilizing Positron Emission Tomography. Continued development of advanced tomographic systems will have immediate medical implications in evaluation of stroke patients and diagnosis of degenerative brain disorders such as Alzheimer's, Huntington's and Parkinson's disease.

The Carbon Dioxide Research FY 1987 operating request is $13.6 million. Its goal is to develop a sound, quantitative atmospheric carbon dioxide knowledge base to aid in energy policy decisionmaking. It is the position of the Department of Energy that we do not yet have the scientific data base needed to recommend specific, firm energy policy options for consideration of the Congress relating to the potential impacts of CO_2.

Based on projections of potential global impacts, we believe we have the time in which to conduct the research necessary to improve estimates of future atmospheric CO_2. This research will include better estimates of energy usage and the workings of the carbon cycle, and will improve climate modeling to develop regional and seasonal climate estimates as a function of future atmospheric CO_2. These are prime research directions. Because oceans play a major role in the exchange of carbon dioxide with the atmosphere and as a heat engine in relation to global climatic conditions, much more data, analysis and modeling of oceans is required to be able to develop climate and carbon cycle models with which to predict effects of elevated increased atmospheric CO_2 levels. Although improved understanding of the direct effect of elevated CO_2 on crops is beginning to emerge, it is necessary to design experimental methods to determine the first principles which integrate crops, weeds and insects so that an ecological systems model can be developed. Collaborative international research is a necessity if CO_2 research is to be successful, and, to this end, we are working with many international groups and individuals (e.g., PRC, Australia, Switzerland, Canada).

In FY 1986, State-of-the-Art Reports were published on four major components of the Carbon Dioxide Research Program which indicate what we know or do not know and which identify the key uncertainties in our knowledge and recommend research activities. We intend to vigorously pursue the recommendations of these definitive statements to reduce the current uncertainties in the scientific knowledge base to a level required for effective decisionmaking.

The FY 1987 BER budget request for Facility Operations is $12.0 million. These funds provide for the necessary capital equipment and construction needs to support the BER program and its Pacific Northwest Laboratory landlord responsibilities.

Of the $12.0 million, the Capital Equipment request of $8.5 million for FY 1987 is essential for acquiring state-of-the-art equipment, replacement of deterioriated and obsolete instrumentation, and general purpose equipment needs at the Pacific Northwest Laboratory.

The Construction request for FY 1987 is $3.5 million. The request supports the program's General Plant Project needs, and the Pacific Northwest Laboratory landlord responsibility. General plant projects are necessary to accommodate continuing requirements to maintain satisfactory and economic operating conditions, to meet regulatory requirements and to provide for new program developments.

The FY 1987 request for Program Direction is $3.6 million. These funds are required to provide for the personnel costs of 53 full-time equivalents to direct, manage, and support these multidisciplinary research efforts.

This completes my summary of the BER program. I would now like to discuss the several outlay programs that are related to my statutory responsibilities to advise the Secretary on DOE energy R&D programs, the non-weapons multiprogram laboratories, and the education and training of scientists and engineers.

ADVISORY AND ASSESSMENT ACTIVITIES

Within the Office of Energy Research, the Office of Field Operations Management (FOM) and the Office of Program Analysis (OPA) support the Director's statutory advisory responsibilities. The Office of Field Operations Management provides support with regard to management oversight of the laboratories and energy-related manpower development and training activities of the Department. The Office has developed policies and several management tools that the Department uses to administer its laboratories and R&D facilities across the country. The office also manages the University Research Support, the University Research Instrumentation, and the Multiprogram Energy Laboratories-Facilities Support programs, each of which I will discuss shortly. The Energy Research Analysis program, managed by the Office of Program Analysis, on the other hand, provides independent and objective program analyses and technical assessments.

ENERGY RESEARCH ANALYSIS

The Energy Research Analysis (ERA) program is the only Departmental program specifically designed to provide independent technical assessments of DOE programs. One of the program's principal tasks is to solicit and obtain credible judgments by premier researchers and expert scientists of the quality of DOE-supported science and its eventual impact. Often following

from these judgments are recommendations on the necessary next steps for the research. These recommendations provide independent views on future program directions for DOE program managers to consider. This method of technical review has evolved over the past 5 years with participation by several hundred industry, academic, and laboratory researchers.

Recent accomplishments include technology assessments of fuel cell research, wind turbodynamics, nonhighway transportation, and light water reactor automation. A comprehensive review of the low level radioactive waste technologies was also accomplished resulting in recommendations for future research and development. A program assessment of the Oak Ridge National Laboratory's exploratory fund program, which reflects a broadly supportive program for new and innovative research ideas, is being published. The success of this exploratory fund program is one of the reasons for my support of such activities.

In the area of acid rain, the Office of Program Analysis continues to represent DOE on the Interagency Task Force on Acid Precipitation. This Task Force plans, coordinates, assesses and establishes the budgets for all Federal acid rain research. Peer reviews of the research into materials damage caused by acid rain have been held recently, resulting in directions for future research to clearly establish any deleterious effects of acid rain. These and other assessments are focusing on 1987 as a key year for identifying and quantifying acid rain impacts. The Energy Research Analysis program has been instrumental in bringing research to bear on this and similar issues. In addition, a National Laboratory Consortium mandated by the Energy Security Act of 1980 (P.L. 96-294) (ESA), composed of four National laboratories (Brookhaven, Argonne, Pacific Northwest, and Oak

Ridge), is carrying out the comprehensive multi-year research effort provided for under section 704 of ESA to explain the impacts of acid rain, in addition to their roles as Task Force members.

The FY 1987 budget request for the Energy Research Analysis program is $3.5 million. It provides for (1) one to two independent analyses of the accomplishments of DOE R&D programs, (2) two to three assessments of technologies, (3) support for assessment and coordination elements within the National Acid Precipitation Assessment Program (NAPAP), including DOE's share of the support for the NAPAP Director of Research, (4) support of groups such as the Energy Research Advisory Board (ERAB) and JASON, and (5) technical support on issue papers and alternative action studies.

UNIVERSITY RESEARCH SUPPORT

The goal of the University Research Support (URS) program is to help maintain strong scientific/technical research capabilities in support of the Department's long-range energy R&D mission. To accomplish this goal, the URS program provides a special Departmental focus for a number of efforts which primarily involve universities and university faculty and students, both directly and in conjunction with the Department's national laboratories. The goals of these interrelated efforts are to:

- Maintain and strengthen university-based energy research and manpower development capabilities in selected high priority energy research fields.
- Use the unique resources of the national laboratories (equipment, instrumentation and personnel) to assist in university faculty and student research manpower development.

- o Assist in the transfer of laboratory-developed technology and expertise to the university and private sector.
- o Increase the number and enhance the quality of students, including women and minorities, pursuing professional level degrees in energy-related science and engineering.
- o Help strengthen the scientific/technical workforce in the Department's national laboratories.

With an FY 1987 budget request of $11.0 million in Operating Expenses, the URS program consists of two major subprograms (Table 13). The first of these is the University/Laboratory Research subprogram, with an FY 1987 Operating Expenses budget request of $9.7 million. This subprogram supports both the University/Laboratory Cooperative Research and University Reactor Fuel Assistance efforts. One of the objectives of the Laboratory Cooperative Research activity is to enhance the quality of students pursuing future careers in science or engineering by involving them in ongoing laboratory research programs. This approach offers the added benefit of making additional research capabilities available to participating university faculty. The second subprogram is Energy Manpower Development with an FY 1987 Operating Expenses request of $1.3 million. This subprogram combines two manpower-oriented activities. The Manpower Assessment activity conducts assessments and analyses of the supply and demand of manpower for both current and future energy R&D programs. The Energy Education and Training activity supports projects directed at encouraging secondary school students to pursue energy-related science and engineering programs at the college level.

Table 13
University Research Support
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses				
University Laboratory Research				
University Laboratory Cooperative Research	$ 6.5	$ 6.0	$ 5.8	$ 7.8
University Research Fuel Assistance	2.8	3.9	3.7	1.9
Subtotal	$ 9.3	$ 9.9	$ 9.5	$ 9.7
Energy Manpower Development				
Energy Manpower Assessment	0.5	0.4	0.4	0.5
Energy Education & Training	0.3	0.4	0.4	0.8
Subtotal	0.8	0.8	0.8	1.3
Total University Research Support	$10.1	$10.7	$10.3	$11.0

The FY 1987 budget request for the URS program specifically includes: (1) support for approximately 2500 student and faculty research participation appointments and special training appointments at the Department's labs and major contractors; (2) support for joint research and manpower development efforts involving the DOE laboratories and Historically Black Colleges and Universities; (3) support for 20 Prefreshman Engineering Program Projects that will reach over 2500 junior and senior high school students, and for high school science student institutes at selected DOE laboratories; (4) cost-shared research support for 30 visiting industrial scientists through the joint DOE National Laboratory-Industry Technology Transfer Exchange Research Program; (5) updated manpower assessments for future professional level manpower requirements (e.g., scientists and engineers) for DOE research programs; and (6) refueling of 7 university reactors and approximately 20 reactor sharing grants to be made on a competitive basis. This latter activity falls under the University Reactor Fuel Assistance program which provides fuel for university research and training reactors. The national nuclear reactor and manpower development effort is highly dependent on these specialized facilities not only for nuclear-related training but also for research in the basic sciences.

UNIVERSITY RESEARCH INSTRUMENTATION

Direct access to state-of-the-art scientific research instrumentation equipment is essential for continued progress in advanced, energy-related scientific and technical research. For example, frontier-level materials research in surface science and catalysis requires the ability to describe what is occurring at atomic and molecular levels. This research is

essential for understanding such phenomena as carbon gasification, and the composition of surface gases. Instruments used in this research must be able to detect and identify materials at the parts per billion level.

Another example is in the field of biological energy research where a major limitation is in understanding the key proteins which influence physiological and genetic factors related to plant productivity. Advances in the analytical capacity of mass spectrometry now offer biological scientists possibilities for approaching this problem.

Many university scientists do not have direct access to sophisticated, state-of-the-art scientific research instrumentation. This is a serious national problem which is being addressed through the combined efforts of Federal science agencies, state governments, private industry and by the university community itself. The Federal effort is coordinated by the Office of Science and Technology Policy through the Interagency Committee on University Research Instrumentation chaired by the Deputy Director of the National Science Foundation. Each participating Federal agency is responsible for supporting university research instrumentation in relation to agency missions and programmatic needs. The DOE response to this overall national effort is the University Research Instrumentation Program initiated in FY 1984 to help support the purchase on a competitive basis by university researchers of state-of-the-art instrumentation.

The FY 1987 request for the University Research Instrumentation program is $5.0 million. This level will support an estimated 15 to 18 competitively selected awards for instrumentation costing over $100,000. Typical instruments supported in prior years include microprobes, electron and

scanning microscopes, laser systems and spectrometers. As in prior years, the program will concentrate on those university research groups which have already demonstrated expertise in one of a small number of high priority energy-related topics which are of special concern to the Department's research programs. Among the research topics to be considered in FY 1987 are catalysis, bioconversion, engineering research including materials, the geological sciences, and environmental research. Each award will be cost-shared with the selected university.

MULTIPROGRAM ENERGY LABORATORIES-FACILITIES SUPPORT

The FY 1987 request for the Multiprogram Energy Laboratories-Facilities Support (MEL-FS) program is $60.2 million (Table 14). The MEL-FS program consists of two subprograms: Multiprogram Energy Laboratories-General Purpose Facilities (MEL-GPF), initiated in FY 1981, and Environmental Compliance, initiated in FY 1985. The goal of the MEL-GPF subprogram, which is managed for the Department by the Office of Energy Research, is to rehabilitate and replace multiprogram general support facilities that are essential to continued operations of the Department's multiprogram laboratory sites. These support facilities include site utilities and support buildings such as laboratories, office buildings and warehouses, roads and railroads, which represent a multibillion dollar Government investment.

Through continued use and aging, support facilities deteriorate to a point where they are no longer capable of performing their intended functions and must be rehabilitated or replaced. The MEL-GPF program systematically reduces the backlog of deficiencies of these support facilities. It

Table 14
Multiprogram Energy Laboratories-Facilities Support
Budget Authority
($ in millions)

	FY 1985 Conf. Approp.	FY 1986 Conf. Approp.	FY 1986 Adjusted	FY 1987 Request
Operating Expenses				
Environmental Compliance	$ 0	$10.4	$ 9.3	$14.3
Capital Equipment				
Environmental Compliance	0	1.0	1.0	1.0
Construction				
Multiprogram Energy General Purpose Facilities	33.2	23.7	22.8	34.9
Environmental Compliance	0	7.0	6.7	10.0
Total MEL-FS	$33.2*	$42.1	$39.8	$60.2

*A reprogramming, approved in April 1985, transferred $5.4 million to this activity.

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reflects an appropriate Federal responsibility for management of the Government's real property, and we plan to continue the program as a necessary cost of doing business as long as the multiprogram laboratory facilities are used to perform research and development functions for the Department.

The FY 1987 Construction budget request for MEL-GPF is $34.9 million (Table 15) and would continue construction on projects begun in prior years, including chilled water facilities at Brookhaven, Oak Ridge and Argonne National Laboratories, replacement of laboratory roofs at Argonne National Laboratory, a fire alarm system at Richland, and fire protection improvements at Brookhaven.

The FY 1987 request includes eight new projects including laboratory restoration at Pacific Northwest Laboratory, piping system restoration and steam distribution system upgrade at Oak Ridge National Laboratory, rehabilitation of laboratory space and waterline replacement at Argonne National Laboratory, mechanical systems rehabilitation at Argonne and Lawrence Berkeley Laboratories and electrical system rehabilitation at Argonne National Laboratory.

Environmental Compliance is a separate subprogram because of the magnitude of the requirements at Oak Ridge National Laboratory. As such, it will identify and correct deficiencies at ORNL to ensure compliance with existing state and Federal regulations. Over the years, ORNL has generated a variety of radioactive and nonradioactive pollutants which were handled in accordance with existing environmental regulations. Since that time, a number of new regulatory requirements have resulted in the application of

Table 15
Multiprogram Energy Laboratories-General Purpose Facilities (MEL-GPF)
Budget Authority
($ in millions)

Construction	TEC	FY 1987 Request
New Projects		
Buildings		
Laboratory Restoration I, PNL (87-R-751)	$ 2.1	$ 2.1
Piping System Restoration, ORNL (87-R-752)	3.8	0.7
Rehabilitate, Laboratory Space (87-R-753) (Building 200), ANL	12.0	1.2
Utilities		
Mechanical Systems Rehabilitation, ANL (87-R-755)	3.2	1.1
Waterline Replacement, ANL (87-R-756)	5.2	1.0
Electrical System Rehabilitation, LBL (87-R-757)	2.6	0.3
Rehabilitate Mechanical Utilities, LBL (87-R-758)	5.5	1.1
Upgrade Steam Distribution System, ORNL (87-R-759)	6.8	2.0
Subtotal New Projects		$ 9.5
Prior Year Ongoing Projects		
Fire Protection Improvements, BNL (86-R-726)	$ 3.0	$ 2.5
Central Chilled Water Facility, BNL (85-R-701)	15.0	5.7
Replace Laboratory Roofs, ANL (85-R-702)	9.8	2.4
Electrical Distribution System Restoration, ORNL (85-R-703)	2.2	1.4
Medical Facility Replacement, LLNL (85-R-706)	7.3	4.0
Replace Site Fire Alarm System, RL (85-R-707)	4.8	1.2
Establish a Central Chilled Water Plant, ANL (85-R-709)	5.2	3.6
Modify Central Chilled Water Plant, ORNL (85-R-712)	4.7	2.6
Road Repairs, RL, LBL, INEL, ANL (84-ER-103)	19.2	2.0
Subtotal Ongoing Projects		$25.4
Total Multiprogram Energy Laboratories - General Purpose Facilities		$34.9

more stringent environmental criteria. As a result, long-established procedures and approaches to handling hazardous wastes are no longer acceptable.

The Department is currently working to fully determine the actions necessary to bring ORNL into compliance with all applicable regulations. The Environmental Compliance FY 1987 budget request of $25.3 million will allow initiation of activities to correct environmental deficiencies at ORNL. The Operating Expenses request of $14.3 million will allow initial activities in the following areas: process waste system upgrades, hazardous and toxic material management improvements; characterization of hazardous and radioactive wastes; determination of potential for ground water contamination in spill sites, holding ponds and White Oak Creek watershed; and upgrades of sanitary and storm sewers. The Capital Equipment request of $1.0 million is for equipment necessary to provide for the cleanup activities. In addition, $3.0 million is for general plant projects (e.g., upgrade of the process waste collection system; goundwater monitoring network, etc.) and $7.0 million is for the Non-radiological Process Waste Treatment Project which will collect and treat the non-radiological waste effluents from ORNL facilities.

ADVISORY AND OVERSIGHT PROGRAM DIRECTION AND POLICY AND MANAGEMENT

The FY 1987 budget request for Advisory and Oversight Program Direction is $2.9 million. The FY 1987 request will provide the staffing resources required by the Director of Energy Research to carry out his responsibilities under legislation (P.L. 95-91) and those assigned or

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delegated by the Secretary in areas beyond the scope of other ongoing Energy Research programs. These funds are required to provide for the salaries, benefits, travel and other expenses associated with 44 full-time equivalents.

The FY 1987 budget request for Policy and Management is $0.5 million. These funds are required to provide for the salaries and related expenses associated with 8 full-time equivalents in the Office of the Director of Energy Research.

Mr. Chairman, that concludes my testimony. I would be happy to answer any questions.

Senator EVANS. Let me defer to the chairman. Mr. Chairman, why don't you go ahead with your questions.

Senator DOMENICI. I do thank you again, Senator Evans.

I still have one major amendment to offer on this tax bill, one that we hope will have the effect of equalizing the tax increases and the tax decreases for budgetary purposes. I greatly appreciate your accommodating me in chairing this and letting me ask some questions now, if I might.

Dr. Trivelpiece, could I start with the SSC Program.

When do you anticipate a decision being made by the Department?

Dr. TRIVELPIECE. I hope very soon. We have had three reviews in the past couple months at the Under Secretary level. These have been to go over the science and its importance, the technology, and can a facility be built, the cost and schedule and other things.

There is a conceptual design report that has been reviewed thoroughly and it has been incorporated in the review. It is necessary now for the information and findings to be presented to the Secretary and I hope that will be done in the near future and we will try to have some kind of decision, at least with respect to the 1988 budget, sometime in the near future.

Senator DOMENICI. Do you have the latest estimate of the program cost?

Dr. TRIVELPIECE. Yes, I do.

Senator DOMENICI. What is it?

Dr. TRIVELPIECE. The construction costs are $3.01 billion. That does not include some of the detectors and computers and R&D, and so on which are estimated to be around $1 billion. That is a flexible number. That will be determined by the number of detectors you would commission immediately, and so on.

If you escalate those costs, it will add another couple billion dollars to it over the 10-year construction period. I think those are quite solid numbers as distinct from previous numbers, $2 to $10 billion being bandied about; $3.01 billion for construction is a very good documented number now.

Senator DOMENICI. There is a chance if it is going to be, it might be in the 1988 budget?

Dr. TRIVELPIECE. That is a possibility.

Senator DOMENICI. Do you think it is more probable it will be delayed?

Dr. TRIVELPIECE. I would hate to speculate at this point in view of the fact I have not given the Secretary an opportunity to review the findings.

Senator DOMENICI. What is the real chance for international collaboration and part payment?

Dr. TRIVELPIECE. If we do proceed, I believe they are excellent. I have met with representatives of the Japanese Government and scientists from Japan on a number of occasions. I believe their interest in joining us in this project is quite high and if we have something concrete to lay on the table, it is my opinion they will be willing to join and subsidize the cost in some appropriate way.

Senator DOMENICI. I have not, myself, made the following statement, but I have heard the distinguished acting chairman indicate that we are having a great deal of difficulty with the siting of ulti-

mately a nuclear waste facility. I think I have heard him say that perhaps that is going to be so difficult that some of these kinds of programs as incentives ought to be tied into a site selection.

Would it be fair to assume that the Department has given some thought to that or not?

Mr. TRIVELPIECE. I can't think of a way of saying it that doesn't make it sound funny, but, yes, with some apprehension, the Department has noted that others have made suggestions along those lines.

Senator EVANS. With some apprehension, you say?

Dr. TRIVELPIECE. Yes; we are obviously trying to keep them as independent, uncorrelated events. I am too well aware of the political system in our country and they may well become correlated as a result thereof.

Senator DOMENICI. With reference to the site selection, do you think that will be determined principally on a technical basis or would you anticipate that there may be some financial incentives to be offered by the States built into the itinerary for the selection?

Dr. TRIVELPIECE. My assumption is that there would be some financial incentive offered by the States, given the indications we have received thus far from the various delegations with which I have met.

Our job, however, as I see it, is if we go to receiving proposals, is to review these proposals from a technical merits point of view to try to determine the excellent sites and make that presentation available to the Secretary who in this case would be the source selection official or to whom he would designate that responsibility.

Senator DOMENICI. I don't know how the distinguished acting chairman and ranking member feel about that, but it does seem to me that those that have it, have the most of it, more in terms of contributing State and local money to this facility, I personally think we are going to get ourselves into a jungle, but maybe that is just because I am not so sure that my relatively poor State will offer an awful lot of money. I have a hunch that Texas and a couple others will.

I have made my statement, in any event. Let me move to the current testimony of yours.

Senator EVANS. Let me associate myself enthusiastically with that statement. I think this has happened in too many other instances, becoming a commonplace effort, and I think an extraordinarily wrong way to make very important decisions. We ought not to use $1 of local funds as indicator of where things ought to go.

Senator DOMENICI. Let me move on to some of the facilities and projects, if I may. I will try to go quickly.

You mentioned in your testimony due to relaxation in the energy crisis situation, there is now less urgency to defer an energy supply system based on nuclear fusion principals. I am talking about magnetic fusion energy and a revised magnetic fusion energy program was put into place last year.

Do you have any specific target dates for commercialization of magnetic fusion energy and do you have enough trained scientists and engineers when we need magnetic fusion energy?

Dr. TRIVELPIECE. There is no particular date that is in mind for commercialization. To some extent it is a self-fulfilling prophecy.

We have reached the point in magnetic fusion that we will see achieved this year in the tokamak in Princeton that more energy is released than that invested in containing the plasma.

That does not necessarily translate directly into a commercial reactor. There is a substantial quantity of engineering work that needs to be done. The rate at which we can do that is fund determined. If it were to be done faster, then it would require more funding.

As you recall, back in 1973 when we found gaslines, there was a plan to have fusion reactors by the year 2000. That would have required substantial enhanced funding, probably in 1973 on the order of $300 million. We were spending only 30. As time progressed, we have found ourselves in a different situation.

Instead of the supply of oil going to zero and price going to infinity, we have reached the point where it is quite reversed to some extent and at the present time making the case that we need to accelerate fusion is very difficult. However, I think excellent progress is being made.

To your last question, yes, we do have the necessary scientific talent to make progress, particularly when taking into account the activities of other countries as well.

Senator DOMENICI. I have three other questions, one relating to that, another relating to scientists. Let me move for a moment to MFTFB, the mirror fusion test facility.

I understand the President again intends to mothball the mirror fusion test facility at Livermore and it seems to me that the House is adding $25 million to maintain that program.

How much is required to finish that project? I understand up to $100 million.

Dr. TRIVELPIECE. Yes. It is substantially more than that. It would probably in fiscal year 1987 take a minimum of $50 million and the following years somewhere in the $60 or $70 million category to operate a mirror program.

What has happened there is that the bare construction project has been finished, but that does not put the auxilliary components on it which make it possible to operate it such as neutral beam heaters and power supplies. There is more that needs to be added before it can be made into a fully operational facility.

Senator DOMENICI. Your decision to mothball that was based on both budgetary and technical considerations, was it not?

Dr. TRIVELPIECE. It was primarily budgetary, but the technical decision, I think, was that it would impact the rest of the program in an unfortunate way and, therefore, this choice had to be made, given the budget constraints under which we had to live.

Senator DOMENICI. The 16-member advisory committee recommended mothballing, did they not?

Mr. TRIVELPIECE. That was subsequent to the necessity of our making a decision. I did ask the Fusion Advisory Committee to review our decision and they have supported it.

Senator DOMENICI. How does the mirror compare with the Tokamak and the alternate concepts in the area of achieving confinement, at least the parameters of confinement and the reactor prospects? Do you remember?

Dr. TRIVELPIECE. Not off the top of my head, but I believe the figure of merit which is used is density times containment period for the magnetic mirror which is a couple orders of magnitude less than that currently achieved in the present Tokamak experiment.

Senator DOMENICI. If $25 million were added with no strings attached, what would your priority be, MFTFB or the AFC, such as Spheromak?

Dr. TRIVELPIECE. We have still yet to determine precisely what is meant by the House language. My understanding is that some of it would be for other activities in the mirror program other than the MFTFB, but the exact allocation would remain to be determined until after discussions with the House Appropriations Committee.

Some of it would go for the Livermore Mirror Program. Some of it would go to mirror programs which we also have at MIT and the University of Wisconsin, and to other parts of the program as indicated in the committee report.

Senator DOMENICI. The questions that I did not ask, I will submit for the record, and ask that you answer them at your earliest convenience.

I thank you for accommodating us today. As usual, you have done that on rather short notice and we appreciate it.

D. TRIVELPIECE. Thank you.

Senator DOMENICI. Thank you, Mr. Chairman.

Senator EVANS. Senator Ford.

Senator FORD. I have no questions.

Senator EVANS. Dr. Trivelpiece, I hesitate, I am so fascinated reading your testimony because I learn more than I can understand about the nature of basic physics. I hesitate to even ask questions because I won't understand the answers. I am fascinated by the statement on page 5:

> The most significant recent experimental results all reinforce the predictions of the Standard Model. Although no deviations have been found from it, scientists believe that the Standard Model cannot be the final answer because it does not explain the origin of mass and it does not include gravity (one of the four forces of nature).

Backing off from just tomorrow's, or today's budgetary request, can you describe the nature of research that would be required?

Where do we look and what are the most likely and promising directions to either enhance the Standard Model, change it to a new improved Standard Model, or to get at some of the things that have not yet been explained?

Dr. TRIVELPIECE. I hope my answer does not imply I think you are a straight man for a good question, but essentially the answer is the Super Conducting or Super Collider. The reason is in the Standard Model what is known is that there is a collection of quarks and leptons. These combine to form various things. Two up quarks and a down quark form a proton, two downs and an up form a neutron. Many of the protons and neutions together with electrons form the elements we are familiar with, hydrogen, helium, and so on.

The picture of that Standard Model is that it predicted a number of things.

One of the things was the existence of the W plus and minus particles. These particles were sought for and found in experiments

that were done at CERN. A large piece of the puzzle was fitted there on the spot. There were certain aspects of the theoretical predictions made, they are theoretical predictions, something that nobody has seen. They go to the laboratory, they find these objects and these objects confirm certain features of the theory.

Senator EVANS. That has been verified at certain other labs as well?

Dr. TRIVELPIECE. No. That experimental discovery was primarily done by the CERN Lab, but I don't think the results are in doubt.

One of the interesting things about the W plus and minus particles is that they have a mass that is 80 times the mass of the proton. What is interesting about this is that one aspect of high energy physics involves like driving two automobiles together at high speed and trying to discover what the characteristrics of the automobiles are by looking at the parts that fly out. You might expect to find pistons, rings and engines, but it would come somewhat of a shock——

Senator EVANS. Modern cars would be plastic junk.

Mr. TRIVELPIECE. It would come somewhat as a surprise if you drove two automobiles together at high speed and what came out was a tricycle, a Mack truck and two bulldozers.

To some extent, that is what happens, that the energy equation $E\text{-}Mc^2$, it goes in both directions. You can cause mass diversion to energy in nuclear reactors, fission and fusion reactors, but also if you have energy highly concentrated in a small physical volume, out of it will condense mass.

The way by which that is done at CERN is that two particles, protons and anti-protons, are brought together at high speed. They annhilate each up and give off energy.

In addition to that, because they have excess speed, the excess speed causes energy associated with that motion to be concentrated in a small volume of space. The energy in that volume of space condenses out to plus and minus particles.

The Standard Model also predicts things that have a mass range that instead of being 80 times a proton mass is something like a 1,000 times a proton mass or 1,000 TEV mass range. In order to have enough excess energy left over for something to condense out at one TEV mass range, it means that the incoming particles have to be at energies of 20 TEV's in the center of mass.

Senator EVANS. Presumably that would be a new kind or ratification of a new kind of particle?

Dr. TRIVELPIECE. It would verify certain theoretical predictions which follow from the Standard Model and perhaps lead to an understanding of what the origin of some of the masses are. That energy is the energy which has been chosen for the SSC because it is the facility that will help resolve the answers to these questions.

So, you need that kind of tool. You ask what tool. In addition to that, obviously, certain theoretical studies need to go on at the same time. High energy physics is up against a stop at the moment in which the facilities which it has will not cause energies at sufficient intensities to result in resolving some of the theoretical issues raised by the standard model.

Senator EVANS. What was the facility that was big enough to get us where we are now?

Dr. TRIVELPIECE. It is the CERN facility, SPS, in Geneva, Switzerland, and it produces about 300 GEV particles, rotons hitting antiprotons of the same energy.

Senator EVANS. Would you have some suggested or recommended to the Congress proceeding ahead on SSC unless we already had a previous machine and had seen the results and verified what had gone on beforehand?

In other words, does one come before the other?

Dr. TRIVELPIECE. It is certainly comforting to have those discoveries in place. However, we had started the process of doing the research to determine what the costs and other technical features of the SSC would be before those discoveries were made. They certainly had an influence in the decision regarding the termination of the Isabel project at Brookhaven and the initiation of the research which we hope will lead to the SSC.

Senator EVANS. Are you now at a point where studies are being conducted and some ideas gathered as to what would come next after an SSC?

Dr. TRIVELPIECE. I am sure there are people out there thinking about that. Right now my plate is sort of full.

Senator EVANS. Are we unlike the situation where we had before that before we went to CERN, we had already started looking and had some pretty good ideas as to what we wanted to go next or what we have to jump over?

At this point we didn't have anything beyond SSC to look at?

Dr. TRIVELPIECE. I think the dominating characteristics of human beings other than their desire to survive is curiosity. I am sure something like SSC will raise a collection of questions which will cause curiosity to be driven to want to seek answers to questions that are raised.

Each time in high energy physics when things seem to be at a stop, some technical discovery has permitted us to go to higher and higher energies. In this case, I don't think it would have been realistic to plan to build the SSC, had it not been for the superconducting magnetic accelerator being built at the Fermi Lab that provides a technical basis for being able to say that.

Whether or not somebody is going to come along in a few years and make an invention which instead of having 1 million volts per meter of length, as the accelerating gradient in the accelerator to where it is 100 or 1,000 megavolts per meter, I would be hard pressed to say.

There are other people worried about trying to invent new schemes for making accelerators at progressively higher energies. It may be that at some stage the techniques for SSC will be obsolete. That certainly does not appear to be in the cards over the time scale we are talking about building and operating it.

That is the interesting thing about discovery. You can't stop it from happening.

Senator EVANS. Would you say it is also in terms of the area in which you are operating, the edges of knowledge and seeking of new knowledge in basic research, that it is generally a sequential operation, you build on what you have already learned and what you have done and you can't just throw money at it and have it all happen at once?

Dr. TRIVELPIECE. Absolutely; that goes back a long time. I may have the quote wrong, but I think Izaac Newton said he could see so far because he stood on the shoulders of giants. I think that is a pyramid that goes on indefinitely.

Senator EVANS: It is way outside of our subject today, but I suggest the same thing applies to our SDI program. We have to have shoulders to stand on before we move too far ahead.

Senator FORD.

Senator FORD. Mr. Chairman, I have no questions, but I am going to have to go, as we always do, for other meetings. Senator Bradley is required to be on the Senate floor in relation to the tax bill.

He asked that a statement of his be included in the record. He has four questions for Dr. Trivelpiece that he would like to have him answer in writing, if he would, please, sir.

Dr. TRIVELPIECE. Surely.

Senator FORD. I submit those questions.

[The statement of Senator Bradley follows:]

FEDERAL FUNDING OF FUSION RESEARCH

Committee on Energy and Natural Resources

Subcommittee on Energy Research and Development

Statement By Senator Bill Bradley

June 23,1986

MR. CHAIRMAN, decisions on fiscal year (FY) 1987 funding for energy research and development will greatly impact the direction of our energy supply for the coming decades. Many studies have indicated the difficulties associated with traditional sources of power. Acid rain continues to threaten our forests, carbon dioxide generation raises the specter of a global warming of the atmosphere, and the recent disaster in Chernobyl has highlighted problems with conventional nuclear power plants.

We must maintain a funding level of at least the FY86 post-sequester appropriation for a potentially safe, environmentally acceptable energy source: the Department of Energy's Magnetic Fusion Program.

The United States is the leader of the world's fusion research program. However, the budget cuts of the last few years have caused many important initiatives to be delayed. Most importantly, the deuterium-tritium "breakeven" experiment on the Tokamak Fusion Test Reactor (TFTR) at the

Princeton Plasma Physics Laboratory has been postponed to August 1989.

In addition, the President's FY87 budget calls for closing the TWX-U device at Lawrence Livermore National Laboratories, and the Princeton Large Torus, as well as phasing out several smaller mirror and tokamak experiments. The President's cuts would also make it difficult for the US to lead a proposed multinational collaboration project. The success of this project, which includes the construction in the US of a Compact Ignition Tokamak (CIT), depends on the TFTR providing comprehensive "check point" data.

By maintaining the FY86 appropriation as a minimum level for the Magnetic Fusion Program, Congress can help fusion scientists meet their long-term goals and development schedule. I believe that losing the opportunity to move forward with the program would adversely impact our energy security and our quest for safer, cleaner forms of power.

MR CHAIRMAN, I wish to ask the witness two questions: I understand the CIT is being reviewed this summer. How does this device fit into the program for international collaboration? Could you also elaborate on your current goals and objectives for the fusion program generally?

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DOE SPONSORED RADON RESEARCH

Committee on Energy and Natural Resources

Subcommittee on Energy Research and Development

Statement by Senator Bill Bradley

June 23, 1986

MR. CHAIRMAN, the possibility of widespread human exposure to radon gas was slow to dawn on the U.S. public. It is now, however, a focus of attention because of reports of extremely high levels of the gas in many homes.

Radon is a problem because its radioactive decay products are short-lived nuclides that can become deposited in the lungs and lead to lung cancer. The problem arose first among underground uranium miners who were found to be exposed to high levels of radon in the mines. Studies of those miners years later provide the only direct evidence of the impact and risks of radon exposure on people. But in the last few years, what was once considered a problem for those working or living near uranium or phosphate mines has refocused on houses built over geologic formations that emit radon.

Scientists have found high concentrations of indoor radon in many parts of the country including the States of Washington, Montana, Idaho, Florida, Maine, and Colorado. But the highest radon levels thus far measured in our country have been found in and near the Reading Prong, a geological

formation rich in uranium ores which reaches through sections of Pennsylvania, New Jersey and New York.

The studies of underground miners throughout the world shows statistically significant increased risk of lung cancer in miners exposed to 80 to 100 working level months (WLM). A working level is the traditional unit for measuring radon exposure. It is so named because one working level used to be the highest radiation exposure allowed in the workplace. Data from U.S. miners who experienced large increases in lung cancer rates showed that their highest exposures were around 8,000 to 10,000 WLM. In some homes in and near the Reading Prong, exposure rates are over several hundred WLM per year. Lifetime exposures at these rates would lead to cumulative exposures considerably higher than the most heavily exposed miners experienced.

Concern over indoor radon pollution has prompted both the government and researchers to learn more about radon--particularly about how to retrofit homes to reduce radon exposure. This research is vitally important. However, we still have little understanding of the health fisks of indoor radon exposure.

To illustrate the public confusion surrounding radon health risks, consider some views of government agencies and researchers. The Federal Centers for Disease Control says that radon-related lung cancer may be killing as many as

30,000 Americans a year, yet the American Cancer Society is not issuing any official warnings about radon's dangers. There is no consensus on how much radon the public should tolerate. The little research on residential radon exposure is contradictory, with some studies finding ties between indoor radon and lung cancer, and some not. One theory holds that children are more sensitive than adults to radon exposure. Other scientists speculate that children are in less danger because their bodies have more time to repair radiation damage before the onset of lung cancer.

The response of Federal and state officials to these uncertainties has been to take the road of caution. They cannot afford to wait for incontrovertible evidence that radon is as lethal as they think it may be. I support this approach. It is a responsible reaction.

However, this course of action dictates an aggressive research effort directed at the uncertainties surrounding indoor radon. And an assessment of public health risks must be an important concern of our research efforts.

The Department of Energy's Office of Energy Research has been a major sponsor of radon-related research for several decades. Under its auspices, considerable information has been gathered from laboratory animal studies, studies of radon transport and diffusion into and within structures, and

basic but related studies of internally deposited radioactive emitters. In addition, the Office has augmented earlier studies on uranium miners with recent research of miners in New Mexico. Nevertheless, our knowledge is still neither general enough to yield predictive principles, nor quantitative enough to allow the accurate risk analysis on which rational policy decisions must rest. Furthermore, I am concerned that research efforts have largely ignored the effects of radon exposure on residents of Eastern Pennsylvania and New Jersey-- acknowledged to be the areas of the most serious concern.

MR. CHAIRMAN, it is my belief that the Department of Energy should allocate more of its resources to study the health risks associated with exposure of radon gas in homes. And these studies should be concentrated in regions where radon levels are especially high.

Senator EVANS. Those will be submitted for the record.

Senator FORD. Thank you, Mr. Chairman.

Senator EVANS. Dr. Trivelpiece, let me turn to something a little more pragmatic, I guess.

You were responsible, I understand, for negotiating and planning with the National Academy on the technical review of the N reactor at Hanford?

Dr. TRIVELPIECE. That is right. Not just the N reactor, but for all 11 class A reactors which the Department has.

Senator EVANS. Could you describe the nature of that and is there any information on that operating reactor design that the academy panel will not have access to in their review or do they have total access to everything in their review?

Dr. TRIVELPIECE. I haven't been given any reason to believe they won't have total access to all the information they need.

Senator EVANS. Will that have the impact of making certain portions of their review or their study not releasable to the general public because it will be based on classified information?

Mr. TRIVELPIECE. That is entirely possible. However, I think the desire would be to try to have a report from them that could be totally unclassified with perhaps references to classified portions, should that be necessary.

Senator EVANS. Will you submit a copy of the memorandum of understanding to the Committee for the record?

Mr. TRIVELPIECE. Yes; it doesn't exist yet. What exists is a letter from the Secretary to the President of the two academies and letter from them back indicating a willingness to do this. It is then incumbent on them to develop a statement of work which they are in the process of doing and then that statement of work gets funded by the Department. There is a formal process it has to go through.

[The letters follow:]

NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE WASHINGTON, D. C. 20418

OFFICE OF THE CHAIRMAN

May 15, 1986

The Honorable
John S. Herrington
The Secretary of Energy
Washington, D.C. 20585

Dear Secretary Herrington:

We have received your letter of May 13 asking for an assessment of safety and technical issues raised by the nuclear reactor accident at Chernobyl. We agree that the Academies, working through the National Research Council, constitute a mechanism that can provide an independent review that can be of value to both the Department and the American public.

Members of our staff have already begun discussions with Dr. Trivelpiece and others in the Department so that we can begin our review as soon as possible. We expect shortly to have developed a scope of work that will address the important issues; we will then convene a panel of experts to carry out the assessment.

Yours sincerely,

Frank Press
Chairman

Robert M. White
Vice Chairman

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

May 13, 1986

Dr. Frank Press
President
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Dear Dr. Press:

I would like to invite the National Academy of Sciences and the National Academy of Engineering to provide the Department of Energy with an independent assessment of safety and technical issues raised by the nuclear reactor accident at Chernobyl. The focus of this assessment will be DOE's major research and production reactors.

As you know, I have already taken several steps to review internally our nuclear reactor operations, including:

- a Special Safety Review of the N Reactor (the Department's only graphite moderated reactor) at Hanford, Washington;
- a Design Review of the N Reactor; and,
- accelerated Technical Safety Appraisals of N Reactor and the four production reactors at Savannah River.

I have invited a group of distinguished scientists and engineers to serve as special consultants to determine if there are any technical or safety issues raised by the Chernobyl accident that apply to the operation of N Reactor.

The public stature and expertise that NAS and NAE can bring to an independent assessment would, in my judgment, enhance our internal review process. I expect that your assessment would be conducted in a manner that would allow for appropriate public participation in the review process.

While I am confident that DOE's reactors are designed, constructed and operated safely, I want to make certain that we have thoroughly examined all aspects of the nuclear safety issue in light of the Soviet accident. My objective is to reassure ourselves and the public that our confidence in the safety of DOE's nuclear reactor operations is well-founded.

I have asked Dr. Alvin Trivelpiece, Director of Energy Research, to work with NAS and NAE in this effort.

Yours truly,

John S. Herrington

John S. Herrington

cc: Dr. Robert M. White
President
National Academy of Engineering
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

May 13, 1986

Dr. Robert M. White
President
National Academy of Engineering
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

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- a Design Review of the N Reactor; and,
- accelerated Technical Safety Appraisals of N Reactor and the four production reactors at Savannah River.

I have invited a group of distinguished scientists and engineers to serve as special consultants to determine if there are any technical or safety issues raised by the Chernobyl accident that apply to the operation of N Reactor.

The public stature and expertise that NAS and NAE can bring to an independent assessment would, in my judgment, enhance our internal review process. I expect that your assessment would be conducted in a manner that would allow for appropriate public participation in the review process.

While I am confident that DOE's reactors are designed, constructed and operated safely, I want to make certain that we have thoroughly examined all aspects of the nuclear safety issue in light of the Soviet accident. My objective is to reassure ourselves and the public that our confidence in the safety of DOE's nuclear reactor operations is well-founded.

I have asked Dr. Alvin Trivelpiece, Director of Energy Research, to work with NAS and NAE in this effort.

Yours truly,

John S. Herrington

John S. Herrington

cc: Dr. Frank Press
President
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Senator EVANS. That would be as close as you could come, that would be in the nature of a memorandum of understanding?

Dr. TRIVELPIECE. Yes; we have not yet received from them their final version of what they propose as a statement of work nor their indication of who they plan to have as members.

Senator EVANS. When it is completed, it will be helpful to have that for the record.

Dr. TRIVELPIECE. Surely.

Senator EVANS. I understand you visited Batelle Labs a short time ago.

Do you have any observations generally or specifically as to their operations at Hanford and the ways in which those operations could be improved or an assessment of their research goals?

This is not something that is in the nature of a general U.S. problem, but of considerable interest, of course, to the Northwest.

Dr. TRIVELPIECE. The trip that I took there was as part of the overall institutional plan responsibilities I have for the Department with the nonweapons labs. This includes PNL as well as Brookhaven and others. This is an annual event in which the lab presents its institutional plan. It includes not just things in the programmatic area, but in the programmatic areas of the other assistant secretaries as well.

They sometimes send representatives, but not always. In this case there were representatives from some of the other programs there. Dr. Wiley made a presentation during the day as did members of his staff on various aspects of the program.

The review went very well. I think that the things that they are proposing to do are first rate. Many of the programs they have, and I did spend extra time there this year looking at some scientific programs and high pressure gas tomography, and so on, are first class.

They are having some problems, I think, which are stemming from the changes in the character of the work that is supported there in the nuclear program, modifications, but as a scientific lab, they are coming along and their work in biology has been first class for many years. Molecular, toxicology, and so on, basic work has been done there.

I was trying to remember what I said at the end of my day there in terms of telling Dr. Wiley and others what I thought of it. I can't remember exactly what I said, but I complimented them on having done a very good job in both the presentations they had done during the day and programs they are managing.

They have aspirations to do new things and those aspirations come in conflict with budget pressure and we try to sort them out with them over the years in terms of things where they can compete well against other individuals who want to do similar or the same kind of work.

Senator EVANS. Are you familiar with the cooperative research program in biokinetics conducted by the Washington State University and Batelle Lab?

Dr. TRIVELPIECE. I am not familiar with it. I have heard about it.

Senator EVANS. Is there work of that nature, that kind of cooperative work in university labs going on in other places in the country?

Dr. TRIVELPIECE. In biology or generally?

Senator EVANS. Generally how much of that kind of cooperative research goes on? How much of it is kept pretty much in-house, either a laboratory or Batelle or university?

Dr. TRIVELPIECE. What I have tried to do since I have had this job is to point out to the labs that they have been somewhat insular in the past and have not tended to interact with the outside community as well as they could or should for their own health and well-being as well as the scientific health and well-being of other activities of the United States.

I have been moderately successful in that. It has been a process of probably nagging and jawboning. But we have influence through the purse strings and I think they pay attention to that. All labs have moved fairly aggressively in that direction.

There are now a number of cooperative programs that involve activities in universities coming to labs, taking advantage of the facilities. The synchrotron light source, the Brookhaven reactor, the reactors at Oak Ridge Lab, the Stanford synchrotron light source, the National Center for Electron Microscopy, all those things are used by universities.

There is a wide collection of arrangements, some of which involve one scientist agreeing with another scientist at another lab to get together in which there is a cooperative program. I encourage them. I think it is up to the lab to take the initiative to try to stimulate those and any reasonable arrangemant has not been refused, to my knowledge.

I will be glad to supply both our user facility manual which describes these for the record as well as having additional information supplied on this subject. I think it is an important ingredient.

[The "User's Guide to DOE Facilities" was retained in subcommittee files; additional information follows:]

COOPERATIVE RESEARCH BETWEEN UNIVERSITIES AND DOE LABS

The various cooperative research relationships between our laboratories and the university community can be grouped into two categories. The first are the historic relationships between several of our laboratories and local universities. For example, the Lawrence Berkeley and Ames Laboratories have strong cooperative research programs with faculty at the Berkeley and Iowa State University campuses respectively. The Lawrence Livermore National Laboratory has a number of cooperative research programs underway with faculty at the Davis campus of the University of California while the Livermore Institute of Geophysics and Planetary Physics, which is one of five branches of a University of California-wide multicampus research unit, makes available to UC researchers in geophysics and astrophysics some of Livermore's unique facilities. We have also been pleased with recent expansions of these local relationships at several of the laboratories, for example, between the Pacific Northwest Laboratory and Washington State University where joint research is now being conducted in molecular biology and genetics. The second category includes a number of cooperative programs centered around specific research topics or programs. For example, the Idaho National Engineering Laboratory and the Massachusetts Institute of Technology are conducting a joint program in engineering research involving 20 MIT faculty members and 50 graduate students working in with INEL staff in four areas: plasma engineering, automated welding, engineering analysis and fracture mechanics/fracture control. INEL has also developed research agreements with 20 universities and colleges in the Rocky Mountain and Pacific Northwest regions. The Argonne National Laboratory recently entered into a cooperative research program in multiphase flow systems with 18 universities in the Midwest. Specific research projects in this general area will be jointly conducted by ANL scientists and university faculty.

The DOE is committed to expanding the cooperation between our laboratories and the university community. All parties benefit from this cooperation: the universities, the national laboratories, and the Department. Ultimately, the real beneficiary of this cooperative is our entire national scientific and technical enterprise.

Senator EVANS. That would be helpful. I asked Ms. Walker about some of these broad issues of global concern. I would like to return to that.

I note in your testimony particularly you mention carbon dioxide. You said in there:

Based on projections of potential global impact, I believe we have the time to conduct research necessary to prove estimates of atmospheric of CO_2. There is a lot appearing in the popular press now about the speed at which that impact might occur, the warming climate, all the kinds of things, some of which may be reasonably accurate, some are pretty high-flying projections.

When you say that you have time, how much time?

I guess the first question is: Is it clear now that there really is a warming trend of the Earth's atmosphere from a buildup of CO_2 or is it possibly another in the many cycles of warming and cooling that we have gone through for centuries, being able to distinguish one from the other?

Dr. TRIVELPIECE. The short answer is that we don't know if CO_2 has caused a temperature change.

The longer answer is that it is clear that there has been in the last century a 25-percent increase in CO_2 in the atmosphere. It has gone from 280 parts per million to 340-some-odd parts per million. Dr. Keeling at the Scripps Institute of Oceanography has made measurements on Mauna Loa, Hawaii since 1952. Ice cores from the Antarctic have given us CO_2 measurements of the past. By measuring CO_2 trapped in bubbles in ice over the past centuries it is possible to determine atmospheric CO_2 level 100, or more years ago.

There is no question but that the amount of CO_2 in the atmosphere has gone up. It is also clear that the rate at which it is going up is relatively constant, 1½ parts per million per year. If that were to continue unabated, certainly in another century we would have something like 600 parts per million.

Now, this is the part where it then gets speculative. There are models which indicate that if you spread CO_2 in the atmosphere, that the radiation will come through and become trapped and that the temperature will increase. I think it is reasonably likely to expect at the 600 parts per million, there would be an increase of 1.5 to 4.5° C.

At the same time, however, we are observing, that some plants increase their production by as much as 80 percent the CO_2 level would be 600 parts per million.

Also it is a source and sink problem. We know what the source is, we are burning fossil fuel. Eighty percent is coming from fossil fuel and 20 percent from deforestation. On the other hand, we believe 50 percent of CO_2 is absorbed by the oceans. We should learn more as to where it is going and how it is getting there.

I think the problem is very important. I don't want to leave the impression by what I have said that I minimize the importance of it. I just don't believe it is urgent because there is clearly a period

of time which will permit us to learn what the sources and sinks are, what the cause and effects are, and so on.

I think to get into the speculation that an increase of 2 degrees would result in 50 inches of increase in the ocean level is very speculative. It may happen. On the other hand, it is speculative at the moment.

So, to do a sound job of trying to understand what the sources and sinks are, it seems to me to be the proper responsibility, and that is the way, as the lead agency, I have tried to guide the efforts in this area, and not go off and do things which are inappropriate, given the scientific evidence we have. There is time to get the information, I believe.

Senator EVANS. You say it is possible. If it is possible and it did occur under those time lines, we would have precious little capacity to do anything about it.

Is that right?

Dr. TRIVELPIECE. The problem is a very serious international problem, too, because the United States in 1950, I think it was, something like 40 percent of the fossil CO_2 going into the atmosphere came from things going on in the United States. We are now down to 25 percent.

Western Europe has gone from something like 34, percent down to 17 percent. On the other hand, Eastern Europe has gone from 16 to 24. As I recall, the developing world has gone from 6 to 12 percent.

So, what you see happening is even if the U. S. were to take unilateral action and stop burning fossil fuel in its entirety, which is a difficult thing to conceive, we are not the sole contributor to the problem.

So, this needs to be understood on a global basis with participation by other countries and before going to them, I think we should be in a position where we have a unassailable collection of facts, before we try to persuade the Third World and lesser developed countries to terminate their development by not burning fossil fuels, that we should confront them with hard facts and not with speculation.

At the moment a lot of it falls within the realm of speculation. There is nothing against doing an absolutely sound job at this. I think it is very important to do so, but I am concerned that we not take precipitous actions, based on incomplete scientific information at this time.

Senator EVANS. You can see the result of going to Third World countries. We went through with that phase and now we are beyond it, but you can't go through that phase.

If that is the potential and you say that, for one thing, it appears to be safe to say that if the level continued to grow and when they got to a certain position, that that very well could have physically the result of higher temperatures and the results we all know of from higher temperatures, doesn't that make even more important the search for alternative energy sources that get everyone out of the fossil fuel business, not just the United States and Western Europe which might have the capacity and money to get into nuclear fusion or a lot more esoteric energy sources, but energy sources that would be beneficial to developing Third World coun-

tries which would be easy for them to use, environmentally benign and not as complex?

Dr. TRIVELPIECE. You state an obvious and highly desirable goal. I am not quite sure how to accomplish it.

Senator EVANS. I am not either.

Are we doing anything significant in research?

We spend billions of dollars in research on exotic nuclear energy development, which may be fine. I don't know what would happen if we spent the same amount of money with the same intensity and same scientific help, anything from photosynthesis to the development and the use of burning of hydrogen as an alternative to fossil fuel—are we really assigning the right kind of priorities given these various global potentials that we have identified?

Dr. TRIVELPIECE. The priorities of which you speak, of course, are very complex sets that are determined, in part, on the basis of technical merits and budgetary pressures, and political pressures as well.

Certainly there are things in the areas of photosynthesis which I think are quite fascinating. The idea that you could make inorganic photosynthesis is quite important.

Can you understand how it is that an electron can be caused to go from a low energy state, to a high energy state, as a result of light shining on it, and remain there, and not give up the light by radiating it away, and back down to the state from which it came, understanding that process is very difficult?

I was at Argonne Lab and saw some effort along these things. They have done remarkable things. There is a complex molecule, in which you can identify the location of the molecule which when irradiated by light generates the electron. You can track half of the electron through the complex molecular structure, down to where it crosses the barrier from which it doesn't return.

Once you understand the chemistry of it in a nonbiological way, you may make an inorganic photosynthesis receptor which would absorb sunlight, elevate it to higher energy state, from which it uses that fuel to convert it back to a lower energy state, without some of the things associated with the burning of fossil fuel.

Whether this is a target or not, I do not know, but I have high hopes that will occur and that is one of the things we should emphasize. Whether or not we should alter the priorities we have, that is a question for debate. Today I am not sure I have a simple answer.

Senator EVANS. I am not sure I do either. I wonder whether that date has been elevated to a high enough, important enough level?

It seems to me we are at a point, where we have a whole series of global problems which we mentioned earlier. They may or may not be as urgent as some suggest or as benign or trivial as others suggest.

It does seem to me we ought to be reviewing pretty carefully whether it is better, and more likely to make breakthroughs in signficant steps forward, in a given time line in a fuel like nuclear fusion, for instance, or in some of these other fields with the end result being an environmentally benign source of energy, to replace the kinds of things that are causing trouble, or whether the same money and the same effort and the same scientists assigned in a

different way, or encouraged in a different way, might get us to a better, cheaper and easier energy to use by smaller countries.

I am not aware that that kind of real high level debate has gone on. Has it?

Dr. TRIVELPIECE. I think there are worlds of future organizations, and so on, energy future organizations to talk about these things.

I am not sure in the sense you are talking about, a set of good priorities has been established. Our own energy research advisory board, debates these matters from time to time and makes recommendations to the Department and has some influence in the outcome of budgetary requests in the future.

Again, there is the overall budgetary-political overlay that comes into play on this as well.

Senator EVANS. I understand that. Ultimately it is a politicial decision by the very nature we are talking about public moneys and congressional and executive process, but it sometimes seems to me that would and could be affected significantly by good information and a serious recommendation to change or modify priorities.

I am not suggesting either you or the Department of Energy does this, but it would be easier to try to anticipate what would be more politically acceptable and kind of arrange the priorities so that they have some really good chance of being accepted and going through.

Can you suggest any way to really elevate this in terms of the understanding of the knowledge of those who do have to make political decisions or within the administration?

An organization on the outside doing private kinds of research, world future organizations, is one thing. I think it is important to have that kind of determination or at least that kind of debate within the Department or administration, between the administration and the Congress, as we start dealing with billions of dollars in our own future.

Dr. TRIVELPIECE. I don't think I have a good answer. I would like to observe that we have been through some very painful pendulum swings of facing up to gaslines one morning, followed by creation of ERDA and DOE, followed by programs which were funded very heavily which got over into the demonstration arena rather intensely and then the energy crisis seems to be abating, at least on a short-term basis, and budget deficit circumstances seem to predominate and there is pressure to cut things back.

It may have been during the period when the demonstration projects were at their peak we were not spending money effectively on some of the things we should have. It is also true when we go through the nadir with this sort of thing, we are not doing some of the things that we should.

How to stabilize that so that proper attention is paid over the long haul to those things which need to be addressed is something I don't have a good answer for. If you have some suggestions, I would be delighted to take a run at trying to make them work.

Senator EVANS. I am not sure I have suggestions. At least I have questions.

I would like to continue this, not at this hearing, but I think it is important for us to try to find some better way. This is absolutely the right time when there is no current energy crisis. It may be a

difficult time, you can't get the people's attention, but I can't think of a better time to try to look at a longer range and have some chance of getting ahead of the game rather than behind it.

You mentioned the fact that we are now diminishing to a degree the work on nuclear fusion because it appears as though we don't need that kind of energy source as rapidly as we once did.

I am sure that you would agree that the gaslines which gave real pressure to some of the energy research we did in the seventies could be back by the end of this century. It is possible because the political decision is made elsewhere or a whole lot of things could happen in the world that we could be right back in the gaslines and in an energy crunch.

So, you can't slow down long-term research on the basis we don't need it, given current circumstances if we know that current circumstances could slip back in the phases of a few years ago very quickly. We wouldn't have time to react.

As always, you present not only excellent testimony, but give me an additional lesson in physics which I think I understood. All I have to say is that it was much simpler when I went to high school and electrons were the smallest element of nature.

Dr. TRIVELPIECE. Right on.

Senator EVANS. Thank you.

Dr. TRIVELPIECE. Thank you, Mr. Chairman.

Senator EVANS. Let us to go the next panel, Dr. Stephen Dean, president, Fusion Power Associates in Gaithersburg, MD.

I understand Dr. Dworkin will be accompanied by Dr. William Ashburn, University of California Medical Center, Department of Nuclear Medicine, and Dr. Alfred Wolf, Department of Chemistry at Brookhaven National Laboratory in New York.

We will start first with Dr. Dean.

STATEMENT OF DR. STEPHEN O. DEAN, PRESIDENT, FUSION POWER ASSOCIATES

Dr. DEAN. Thank you, Senator.

I appreciate having the opportunity to present testimony again this year. Also, I would like to thank you and the members of the Energy Committee for continuing to be interested in energy during these last several years when the energy crisis has been seen to be abated and that people don't want to support energy the way they once did.

Senator EVANS. It is not easy, I tell you.

Dr. DEAN. Not for you or us.

There are two primary reasons for working on fusion which is the energy process that goes on in the Sun.

One is that the fuel supply is universally available, the primary fuel being heavy hydrogen that comes from water. It has been our belief using such a fuel would make a safer world because the fuel would be available to all countries, no country would have a corner on the market. Therefore, it would not be necessary to go to war in order to achieve this fuel when times got tough.

The other primary reason for supporting fusion has always been the safety environmental characteristics of fusion relative to fission where the radioactivity that is produced from a fusion reactor is

much less in quantity and much less dangerous in character than the isotopes produced in fission.

As a matter of fact, I just received a June 5 copy of "Nature" which is a science magazine in England which says the following:

> One lesson to be learned from last month's nuclear accident at Chernobyl is that there should be renewed effort in thermonuclear fusion. This was the opinion offered last week by academician Selikov, Vice President of the Soviet Academy and member of the investigating commission, speaking at a press conference in Moscow.

Fusion has been recognized by all the major countries of the world as a very important undertaking for mankind. It is not that we expect to produce all the world's elecricity in our lifetime, but we hope to ensure a supply of energy in the future for our children and our grandchildren.

It is for this reason the advanced countries of the world have always worked hard on and long together on this difficult problem. The recognition of this is the fact that fusion is one of the primary activities that is on its way as part of the western economic summit progress talks.

There are working groups and parties among the United States, Europe, and Japan that have been for a couple of years now working together to try to plan the best way to use scare resources to develop the scientific and technology of fusion as a western initiative.

Last November, as you know, as a result of the Reagan-Gorbachev summit, the President reported, and it was in their final statement from that meeting, that the two leaders, Gorbachev and Reagan, agreed that the world should work together to develop fusion power and as a result of that, there are now active negotiations at the State Department levels to plan the next generation facility in fusion. So, fusion has been recognized worldwide as an important undertaking.

Fusion in this country has always been a delicate balance of large facilities which are required to prove out the ability to produce these plasma and small-scale facilities which are required to test new ideas and to develop better approaches for the long run.

As the budgets have come down in the past few years, it has been increasingly difficult for the Department of Energy to balance the program in such a way as to maintain our commitment to prove out fusion even in the larger facilities and to maintain the thrust of developing new ideas in the smaller facilities. I think they have done a pretty good job trying to maintain this balance.

However, a crisis emerged last fall. It was in part brought about by the Gramm-Rudman cut and in part brought about, starting from O&M levels, the OMB cut their program even further in their 1987 submission you have under review.

At this point the delicate balance existing in the program became unglued. We had a large $250 million mirror facility that had just finished its construction that we are not able to operate.

As a result of trying to maintain a balance, the Department of Energy made a difficult choice to phase out the entire mirror program. The House Committee on Appropriations just last week recognized that things had gone too far and too fast in cutting back on the fusion program and that this delicate balance in the program had become unglued.

As a result, last week the full House Appropriations Committee recommended an additional $25 million be added this year in order to restore the ability of the Department to maintain a balanced program.

I urge this committee to endorse that add-on. Even with that add-on, the budget for fusion in 1987 will be less than it is this year. If you can do this, I think you will find that the program will be maintained in a healthy state, will not be moving as fast as it could, but at least the important programs that have been built up in the past can be maintained.

I have a written statement which is a little more detailed which I submit for the record.

Thank you.

Senator EVANS. Thank you. Your full statement will be included in the record.

[The prepared statement of Dr. Dean follows:]

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STATEMENT OF
DR. STEPHEN O. DEAN
PRESIDENT
FUSION POWER ASSOCIATES
TO THE
SUBCOMMITTEE ON ENERGY AND DEVELOPMENT
OF THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
JUNE 23, 1986

On June 19 the House Committee on Appropriations approved a recommendation of its Subcommittee on Energy and Water Development to provide increased funding for the DOE magnetic fusion energy program of $25 million above the Administration's FY 1987 request. In support of its action the House Committee called for the maintenance of "a well-integrated effort with relatively stable funding levels and continuity of departmental support." I urge this committee to endorse this action of the House Committee and to work with your colleagues in Senate Appropriations to secure this needed level of funding. Even with these additional funds, funding for magnetic fusion would still be below the FY 1986 level.

It is important that the systematic budget decline of the past few years be halted. New facilities have either recently been completed, are nearing completion or are under construction. It makes no sense to build these facilities unless there is a serious intent to provide the funds for their operation. Furthermore, fusion has become a focal point for discussion of international collaboration both within the Versailles Summit process and at the recent Reagan-Gorbachev Summit. In his report to a joint session of Congress following the Gorbachev Summit, President Reagan stated, "As a potential way of dealing with the energy needs of the world of the future, we have also advocated international cooperation to explore the feasibility of developing fusion energy." It is inconsistent for the Administration to put fusion forth in this way while at the same time recommending a declining budget.

In 1980, the Congress passed the Magnetic Fusion Energy Engineering Act, which specified that the U.S. magnetic fusion program was ready for engineering development and for a focus toward practical applications. The Act further

mandated that the Secretary of Energy should take all necessary steps to ensure the operation of an engineering test reactor by 1990. During the past six years, no actions have been proposed by the Executive Branch which would permit the U.S. to meet the goals and timetables of the Fusion Act. Today, six years later, the U.S. is still ready to proceed with engineering development of fusion power systems. Furthermore, efforts in Europe and Japan are now nearing the point where their programs are scheduled to move into engineering development and the construction of engineering test devices. Now the U.S. is seriously discussing with Europe and Japan, and even with the Soviet Union, the possibility that the world programs should move together towards the construction of a magnetic fusion engineering test device. Although we have lost almost a decade in the timetable of the development of fusion power, at least we still have the basic infrastructure of talent in our laboratories to allow such a device to be conceived and constructed. It is unfortunate that the budgetary cutbacks of the past few years, and the further cutbacks proposed for FY 1987, have resulted in the loss of many industrial scientists and engineers who had been participating in the program. Furthermore, the opportunities that now exist for many of these companies to use their fusion skills to compete for programs in the development of the Strategic Defense Initiative means that it will be difficult for fusion to gain back these industrial people for our program. Nevertheless, I think it is important that the Congress send as strong a signal as possible to U.S. industry that the U.S. has a serious intent to proceed towards the construction of new fusion devices during the next decade and that U.S. industry will be given the opportunity to participate in these projects.

Of course the situation we find ourselves in today has resulted from the so-called "disappearance of the energy crisis" and also from changes in federal policy with respect to the division of responsibility for technology development between the public and private sectors. I believe that the federal government has gone too far in disassociating itself from the responsibility to develop new energy sources. This is very clear in the FY 1987 budget for the Department of Energy. Energy programs have the lowest priority of all programs in the Energy Department. DOE has budgetary increases for weapons and basic sciences, but decreases are again requested for the energy programs. I believe that this Committee must find some way of stopping the continued decline of our national capability to develop and test new energy technologies. The net result of current policies is that, at some future date, the commercial energy technology market will be filled by industries from Europe and Japan. I think this is a very short-sighted policy on the part of the United States.

To some extent, the delays in developing new energy technologies in the U.S. works to the benefit of fusion because fusion is one of the longer-range technologies. The delay of competing technologies, such as breeder reactors, gives fusion the chance to catch up. Thus, for example, fusion is now a credible competitor for military production reactors to make tritium; whereas fusion would not have been a serious competitor if the new production reactors had been initiated in the mid-1980's.

On the other hand, the pace in some areas of the fusion program has clearly been slowed by budgetary stringencies. We are still making rapid progress in the tokamak area based on commitments to new facilities we made in the '70's. But many of those facilities are getting past their peak productivity period. In other cases, such as TFTR and the Big-D device at GA Technologies, the best results are still forthcoming. And we do have some new, more advanced facilities being built. In particular, I note the ATF torsatron device still under construction at ORNL. I also note DOE's intention, as specified in this budget, to construct a new Reversed Field Pinch facility at LANL and a new Field Reversed Concept at Spectra Technologies. I think it is a credit to the program management that these advanced facilities are being built in spite of several years of budgetary decline.

As I am sure you are aware, the Department of Energy has proposed, as a part of their intended 1987 cutbacks, to phase out the U.S. magnetic mirror program. Historically, there have been two primary approaches to magnetic fusion. The closed, or toroidal, systems and the open, or magnetic mirror, systems. Thus, the Department's decision to phase out the magnetic mirror approach means the loss of what has historically been one of the two main magnetic fusion approaches. Such a decision should not be taken lightly. Nor do I believe that it is scientifically desirable that such a decision should be based on budgetary factors alone. A serious peer review of the scientific status and potential of the magnetic mirror line of effort, recently concluded by the DOE, recommends that a national mirror program be continued. The House action would permit continuation of mirror research. Even within the enhanced budgets proposed, the MFTF device at Livermore must still be mothballed because the funds required to make it operational are not available.

As I indicated in my testimony last year, I believe the Department's budget continues to underestimate the importance of systems studies and commercial reactor conceptual design in guiding the R&D programs. The systems studies funding of only a few million dollars, requested in this budget, is indequate and inappropriate for a $300M program with practical goals. Worse, most of the money requested that DOE has called systems studies has been earmarked for near-term machine design rather than for long-term scoping of desirable fusion system characteristics.

Finally, I would again like to request the Committee to take an interest in the inertial confinement fusion program--this year more than ever. A National Academy of Sciences review of this program has recently been completed and it has given the program a strong endorsement. In spite of this endorsement, and in contradiction to the Academy recommendations, the military managers at the Department of Energy do not appear to take pride in, or acknowledge responsibility for, the civilian applications of inertial fusion and they are continuing to try to "bury" the funding for the primary inertial fusion efforts into their weapons R&D activities. The inertial fusion program has made great progress and has great potential for civilian applications and the DOE must be held accountable for its progress. I urge you to see that the budget for inertial fusion remains an identifiable line in the DOE budget.

NEWS FROM

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FOR IMMEDIATE RELEASE
JUNE 25, 1986
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HOUSE COMMITTEE ON APPROPRIATIONS RECOMMENDS ADDING $25 MILLION TO FUSION BUDGET

On June 19 the Committee on Appropriations of the House of Representatives endorsed an increase of $25 million above the President's FY 1987 budget request for magnetic fusion research. In so doing, the full committee accepted the recommendation of its Subcommittee on Energy and Water Development, chaired by Rep. Tom Bevill of Alabama. Fusion Power Associates president Dr. Stephen O. Dean called the action "a clear signal that the U.S. Congress considers fusion research to be an essential national priority to benefit future generations of our citizens."

In a report accompanying its action, the House Committee stated:

> "The Committee, in last year's report, indicated its support of the strategy adopted in the DOE Magnetic Fusion Program Plan to achieve its goal of the establishment of the scientific and technological data base required for the ultimate exploitation of fusion energy. Such a strategy requires a well-integrated effort with relatively stable funding levels and continuity of departmental support.
>
> "The Committee also recognizes the record of innovative contributions to the national magnetic fusion program from the University research programs, as well as the importance of these graduate programs as a source of highly qualified, technologically oriented scientists. As DOE seeks to maintain a proper balance in its support of major program elements, cognizance must be taken of the special needs of these institutions, especially with respect to their role in the exploration of new ideas and of generic problems, and to their commitment to the education and training of graduate students."

The Committee further stated:

"Because of this Committee's concern and belief in the need to maintain a viable magnetic fusion research program, not only for its own value but because of the very important physics research and training that takes place as a result of the fusion program, the recommendation provides for an increase of $25,000,000 above the request to restore a portion of the reductions. These funds are to be used to maintain mirror fusion research as a working alternative so as not to eliminate the primary competitor to Tokamak concepts. In addition, funds are added to maintain the schedule to achieve breakeven at TFTR in the 1988-1990 timeframe. In view of the restoration of funds for the mirror fusion program, the Committee expects that operating support for the Doublet III device be restored to 1986 levels in order to meet international commitments, and to allow neutral beam and RF heating experiments to carry on as previously agreed to with the Japanese, and for the TARA device to provide data support for the MFTF-B. Finally, additional funds may be made available to university research initiatives to assist in maintaining a viable fusion program."

Commenting on international collaboration, the Committee commented:

"Among the proposals endorsed by the international community is the development of an experiment which would provide, at modest cost, the opportunity for detailed investigation of an ignited Tokamak plasma under equilibrium-burn conditions. A preliminary study of such a device, to be constructed in the United States for operation in the early 1990's is now under development and review within the Department of Energy. This experiment would strengthen the United States' position as it continues to negotiate a possible international collaboration program on the larger fusion engineering test facility and would maintain the momentum of the domestic program."

Finally, the Committee report said:

"It appears that the initiative begun during Summit discussions between the United States and the Soviet Union may result in a concrete international fusion project that would result in funding requirements not identified in any budget submission currently before the Congress. Any funding proposed to be obligated on such an initiative, or studies or other activities related to it, shall be presented to the House and Senate Appropriations Committees under the normal reprogramming procedures and identified separately in subsequent budget submissions."

FUSION POWER ASSOCIATES

BOARD OF DIRECTORS

POLICY STATEMENT
1986

The Board of Directors of Fusion Power Associates, on behalf of the association, urges that fusion power development be based upon the following:

RECOMMENDED POLICIES

- Research and development toward an economically-competitive fusion power system should receive high national and international priority.
- Engineering sciences, technology development, systems analyses and plasma sciences should all be considered essential elements in a balanced fusion effort.
- Timely commitments to necessary new and improved experimental facilities are needed to ensure continued program momentum and progress into the 1990's.

The above recommended policies are based upon the following:

FINDINGS AND RECOMMENDATIONS

- Fusion research, world-wide, continues to make outstanding progress.
- Concept improvements are emerging at a rapid rate, giving increasing confidence that an economically-competitive fusion power plant can be developed. Innovative ideas that reduce costs or accelerate knowledge should be expeditiously pursued in all aspects of the fusion program.
- It would be premature, at this stage, to judge which of the variety of magnetic and inertial fusion concepts will ultimately succeed commercially. This fact should not discourage use of the best available concepts in the design and construction of needed fusion test facilities.
- The fusion programs in the U.S., U.S.S.R., Europe and Japan have comparable accomplishments, facilities and momentum. The present rate of progress in the world program is based on capital investment commitments made in the 1970's. Progress will predictably diminish unless next step facilities are developed in a timely manner.
- International cooperative agreements have been a substantial factor in fusion progress and should be encouraged. Such agreements, however, are not an effective substitute for focused national efforts, needed national experimental facilities and subsequent engineering test devices.
- Governments should encourage and promote the full participation of industry in the planning, research and development as well as in engineering and operating aspects of fusion programs. If industry participates in the government - funded R & D programs now, industry will be better prepared to assess the commercial potential of fusion power in the future.
- Governments should foster innovation and optimize utilization of resources by encouraging and strengthening interrelationships among industry, laboratories and universities.
- Fusion - related programs in universities should be selectively strengthened and encouraged to ensure an adequate supply of engineers and physicists with knowledge in this field.
- The governments of the world have made a sustained investment in fusion research. The time has come to begin to capitalize on this investment by placing increased emphasis during the next decade on the engineering and systems design aspects of practical fusion energy systems.

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Senator EVANS. We will turn now to Dr. Dworkin.

STATEMENT OF DR. HOWARD J. DWORKIN, CHIEF, DEPARTMENT OF NUCLEAR MEDICINE, WILLIAM BEAUMONT HOSPITAL, ON BEHALF OF THE AMERICAN COLLEGE OF NUCLEAR PHYSICIANS AND THE SOCIETY OF NUCLEAR MEDICINE, ACCOMPANIED BY DR. WILLIAM ASHBURN, UNIVERSITY OF CALIFORNIA MEDICAL CENTER, DEPARTMENT OF NUCLEAR MEDICINE; DR. ALFRED P. WOLF, DEPARTMENT OF CHEMISTRY, BROOKHAVEN NATIONAL LABORATORY; AND ROBERT WILBUR, DIRECTOR OF THE CONJOINT WASHINGTON OFFICE OF THE SOCIETY AND THE COLLEGE

Dr. DWORKIN. Thank you, Senator.

Mr. Chairman, I am Howard Dworkin, M.D., head of the Nuclear Medicine Department, William Beaumont Hospital, Royal Oak, MI, and president of the Society of Nuclear Medicine.

With me today are William Ashburn, M.D., Department of Nuclear Medicine of the University of California Medical Center in San Diego; Alfred P. Wolf, Ph.D., Brookhaven National Laboratories, and Robert Wilbur, director of the conjoint Washington Office of the Society and the College.

I am here representing the society and the American College of Nuclear Physicians, of which I am a past president. Together these two organizations represent the nuclear medicine community of our country.

Nuclear medicine, one of the most beneficial applications of the peaceful use of nuclear energy, has been expanding with astonishing rapidity in the last 20 years. The diagnostic and therapeutic modalities now offered by nuclear medicine departments are transforming the detection and treatment of cancer, heart disease, and brain disorders, and offer new promise of diagnosis and treatment of neuropsychiatric states. Much of this development in the medical application of nuclear energy has been the direct result of research supported by the Department of Energy.

These two charts show the nuclear technologies for diagnosis and treatment of cancer and heart disease now in clinical practice. Few of these clinical options existed 20 years ago.

These technologies moved already from the research laboratory into daily clinical practice in the hospitals of our country. Many of these technologies not only give us better information and treatment, but replace more expensive invasive procedures. This would not have happened without the DOE research programs in nuclear medicine.

DOE representatives have already cited the areas of research which the Department intends to emphasize in the coming year. Essentially, we support this selection of priorities. In the forefront of research now in the laboratories and beginning to move into clinical practice is the use of positron emission tomography to make more useful images of the heart, of the brain, and of several types of tumors than we have ever achieved before.

Better evaluation of patients in preparation for and following the surgical or pecutaneous treatment of CAD is already possible. Diagnosis of neuropsychiatric states, including epilepsy, the effects of

stroke, Alzheimer's disease, and other types of dementia, and several forms of metastatic cancer are just now becoming possible.

A second major area is the development of radionuclide-labeled monoclonal antibodies which can carry a radiosotope directly to specific cancers. Exploring new ways to use these radiolabeled monoclonal antibodies in the direct diagnosis and treatment of cancer is now the topic of vigorous research.

We have here several illustrations of positron emission tomography made by ECAT III, an advanced PET imaging modality developed by the University of California at Los Angeles under grants from the Department of Energy.

I would like to share these images with you and explain why they are so important. The first of these images to my left demonstrate improvements which have occurred since 1975 in the resolution of brain images. These are slices taken through a phantom of the brain and they show from 1975 to the future in the lower right-hand corner improved anatomical resolution that is possible with a better machine that can now be built.

Senator EVANS. Looking at that, I can't quite read it. Is the upper left one the optimum?

Dr. DWORKIN. The lower right.

Senator EVANS. What is the upper right?

Dr. DWORKIN. That was the original one probably done in the early 1970's. The anatomical resolution has improved with time.

The next group of images is slices taken using the Pedamidgin device from an individual's brain. The individual has Alzheimer's disease and was given radioactive glucose made by the use of a cyclotron. One can see diminished uptake of the radioactive material in certain portions of the brain, principally in the temporal region.

This is rather characteristic of patients with Alzheimer's disease. Such functional images could not be made prior to PET devices.

On the next series of images, again slices through an individual brain, this individual is a manic depressive. In the upper line the individual is in a state of depression. This is decreased uptake of the radioactive glucose.

In the middle line there is increased uptake during the manic phase and the last group of three images at the bottom of the pictorial shows the individual back to a depressive state.

So, we are able to map the level of the metabolic activity in the brain in a patient with various manic depressive states.

The next panel demonstrates images of the heart made with two different types of radioactive material. In the first column radioactive ammonia is used to depict blood flow to the heart.

In the second column we have radioactive glucose used. We are able to show that blood flow and metabolism of glucose are not identical. There are areas of increased uptake in the first set of panels whereas in the second set of panels it is decreased, indicating there is glucose utilization despite the fact there is a decrease in blood flow.

The last set of images, again of the heart, using PET imaging, we are able again to show that with exercise there is increased blood flow. However, the glucose metabolism in certain areas is diminished, corresponding to the blood flow.

All these images would not be possible if we did not have the PET device and sychrotron to produce these active materials.

In conclusion, Mr. Chairman, we strongly support the DOE Nuclear Medicine Research Program. The payoff from this research in recent years has more than justified the expenditures. The promising areas of research now evident will more than repay future investments.

Our only reservation is that the level of $22.1 million requested is not sufficient to take full advantage of the opportunities now evident and to make further advances in instrumentation. Investments made in nuclear medicine research, at this time in history, will, we believe, quickly be repaid by the cost-effective technologies we see on the horizon for better diagnosis and treatment of major diseases.

We recommend an appropriation of at least $23.3 million. This is still not really adequate, but would at least maintain DOE nuclear medicine research at its current level.

On concluding, I would mention that the Society of Nuclear Medicine is holding its annual meeting this week at the Washington Convention Center. We were blessed to receive a welcoming letter from President Reagan noting the advances that have gone on in nuclear medicine research and peaceful use of nuclear energy.

We will be there through noon Wednesday. We have exhibits of all the nuclear medicine equipment and technologies now in clinical use, and a full agenda of scientific programs on both clinical and research applications.

We would be more than delighted to welcome members of the committee and your staffs to these exhibits to see more of what it is that we do today and to discuss what we hope to do next to improve health care in our Nation.

Thank you very much.

[The prepared statement of Dr. Dworkin follows:]

STATEMENT OF

HOWARD J. DWORKIN, M.D.

ON BEHALF OF THE

AMERICAN COLLEGE OF NUCLEAR PHYSICIANS

And

SOCIETY OF NUCLEAR MEDICINE

Concerning The

DEPARTMENT OF ENERGY'S FISCAL YEAR 1987 BUDGET

Before The

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

June 23, 1986

Washington, DC

SUMMARY

The Society of Nuclear Medicine and the American College of Nuclear Physicians recommend an appropriation of $23.3 million for the Nuclear Medicine Applications program of the Department of Energy in Fiscal Year 1987. Although this is significantly below the level needed to adequately support existing facilities or to take full advantage of research opportunities now evident, this appropriation would at least maintain DOE Nuclear Medicine research at its current level.

The Society of Nuclear Medicine is a scientific organization of 10,000 members including physicians, physicists, chemists, radiopharmacists, technologists, and other professionals engaged in the medical use of radioactive materials. The College is a professional organization representing more than 1,200 physicians and scientists actively engaged in the practice of Nuclear Medicine. The combined membership of these two organizations constitute the Nuclear Medicine community of this country.

The application of radioisotopes in the diagnosis and treatment of disease is one of the great accomplishments of the nuclear age. In this era of increasing pressures for cost containment and cost effectiveness in health care, the economic benefits of continued research are even more striking.

Research in Nuclear Medicine undertaken by DOE in recent years is already showing results which more than justify these expenditures. Promising areas of future research are evident which will clearly repay further investments.

Positron emission tomography, which has been developed in large part by DOE laboratories, is providing a new tool to measure metabolic activity. This is already in clinical application in evaluation of cardiac and neuropsychiatric patients. We are learning for the first time how brain function differs from normal, for example, in patients with schizophrenia and Alzheimer's disease. This research must continue to be supported.

Another example is the development of monoclonal antibodies to deliver a radionuclide directly to tumors. This is a promising therapeutic use of Nuclear Medicine which has benefitted from past and present DOE programs.

Many research centers which utilize radioactive tracers depend on the supply of new and of sometimes costly radioisotopes available only from government facilities. For example, Oak Ridge is the sole domestic source of certain stable isotopes necessary for the production of radioisotopes required for heart and pediatric nuclear imaging. Production of these isotopes and their provision to academic researchers is a critical activity of DOE.

It is most important to have the best possible insight into the research most likely to yield advances which can be translated into clinical applications five years off. The Nuclear Medicine community stands ready to assist the DOE -- and, of course, this committee -- in assuring that these research programs continue to prove a wise investment of federal funds.

USES OF NUCLEAR MEDICINE

In a typical Nuclear Medicine procedure, the imaging study, a very small amount of a radioactive preparation is administered by injection. This tracer may be designed specifically to concentrate in one body organ, or to be metabolized or removed from the body by a particular route. Some radioactive drugs are designed to concentrate only in abnormal tissue such as cancer cells or compromised heart muscle. Sophisticated instrumentation records the transit and images the distribution of the radioactive preparation in the body. Data derived from the examination may also be processed by computer, producing improved images and quantitative information about organ function. Organ systems, even specific clusters of cells, routinely examined in this fashion include brain, lungs, liver, kidneys, bone, thyroid, pancreas, heart, and major blood vessels.

Diagnostic in vitro examinations encompass certain tests in which no radioactive material is administered to the patient. Instead, a sample of some body fluid, usually blood, is collected from the patient and reacted with a radioactive reagent in a test tube. These tests are used to determine the presence of hepatitis, pregnancy, and cancer antigens, to determine the precise concentration of various hormones, vitamins and drugs, and to identify pollutants or other toxic materials in the environment. Radioimmunoassay techniques permit early discovery of tumors and matastases before they become evident clinically.

Nuclear Medicine techniques are especially versatile for basic research in the chemical, biological, and physical sciences. Since techniques are similar, data in these areas are easily expanded into clinical research allowing rapid application of information from the research laboratory to clinical practice.

FRONTIERS OF RESEARCH RELATED TO DOE PROGRAMS

The following are a few of many such applications, demonstrating the importance of a continuing high level of research:

(A) Cardiac Nuclear Imaging

One of the most dramatic examples of the rapid transfer of research developments to the hospital is the noninvasive study of the human heart. Heart attacks kill approximately 700,000 people annually and are the leading cause of death in the United States. Almost 300,000 individuals suffer their first heart attack without prior knowledge of having significant coronary disease. Early identification of persons at risk had heretofore

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been particularly difficult. Nuclear diagnostic techniques developed and applied within the past four years are significantly more sensitive and less risky in identifying individuals with diseased coronary arteries (hence at risk) than are other diagnostic methods such as electrocardiographic stress testing, and much less expensive and hazardous than coronary arteriography. Positron emission tomography, developed in large part by DOE laboratories, is the only method of measuring the metabolic activity of heart muscle in a non-invasive manner.

(B) Cancer Patient Evaluation

The major emphasis of Nuclear Medicine in the field of cancer has moved from the therapeutic use of radioactive materials to the use of improved imaging modalities which permit earlier detection and better staging of cancers. In addition, there is growing use of Nuclear Medicine in monitoring the therapy of cancer and early discovery of recurrent or disseminated cancer. This information allows the clinician to continue or modify treatment accordingly. Among the most serious problems in cancer chemotherapy are the serious side effects that anticancer drugs produce. Such effects can often be more efficiently monitored through the use of Nuclear Medicine procedures. For example, certain cancer drugs can adversely affect the heart muscle. Nuclear Medicine methods provide a guide to therapy whereby this toxicity and the possibility of drug induced heart failure can be avoided.

Despite this progress, present technology cannot pinpoint very small growths and often cannot determine their nature. Therefore, these techniques need to be improved by development of more specific radioactive drugs, by exploration of more sophisticated immunologic and biochemical methodology, and by development of instruments with better spatial resolution (such as that offered by emission tomographic techniques). Research with radiolabeled monoclonal antibodies as well as development of compounds that accumulate specifically in receptors only contained in breast tumors are examples of a promising new approach that is being pursued.

(C) Patient Treatment

1. Treatment of Cancer

Improvements in cancer therapy have come about by the development of improved radiotherapy beams, better localization of the tumor, computer-aided treatment planning, and new chemotherapy agents and regimens. Further benefits derived from the use of charged heavy particles (protons, alpha particles, and mesons) arise from better dose distributions, and impressive advantages have been demonstrated in the treatment of benign and malignant growths in the brain. Reduced morbidity and mortality and decreased cost to the patient are achieved from these procedures. The facilities needed for these treatments are only present at DOE National Laboratories and major research centers. Additional support is needed to develop specialized low cost accelerators dedicated for medical purposes.

2. Heavy Ion Therapy

Heavy ions are being used at the Lawrence Berkeley Laboratory for the treatment of blood vessel malformation in the brain. Approximately 10,000 Americans per year are found to have this condition which is not readily treatable surgically. These patients benefit from this new mode of treatment which has been developed with DOE support in the last two years. This program also has proceeded to the treatment of other tumors, with major new successes in the treatment of tumors of the eye and spinal cord.

3. Labeled Monoclonal Antibodies

Labeled monoclonal antibodies offer the promise for the treatment of certain cancers using the specificity of the antibodies to the tumor as a way of localizing the dose. These studies in many instances are provided through collaboration between National Laboratories (Lawrence Berkeley Laboratory, Brookhaven, Los Alamos, Oak Ridge), and Universities (George Washington University, Washington University in St. Louis, University of California at Davis, University of Kentucky, and others).

(D) Instrumentation Development

Important new knowledge of brain function in health and disease has been obtained by the use of positron emission tomography (PET) imaging. PET systems have improved in performance significantly, but the ability to resolve small structures discretely is much less than what is possible and cost is still too high for all but a few research centers. Further improvements in instrumentation are needed to characterize small structures of importance. Developments in high energy physics instrumentation need to be adapted to medical applications to achieve optimal resolution and diminished cost. A five-fold decrease in cost seems realistically achievable with a two-to-three-fold improvement in resolution, given funding for instrumentation support for medical applications at the National Laboratories.

Since PET technology requires an on-site cyclotron and is expensive, the potential of single photon emission tomography (SPECT) is being widely explored. If perfected, this technology would be readily available widely without much additional expense, since the basic instruments are already present in most Nuclear Medicine departments. Research for instrument modification and SPECT radiopharmaceutical development is heavily dependent on DOE support.

(E) Pediatric Nuclear Medicine

Further examples of the improvement in health care from research and development in Nuclear Medicine techniques are in the area of pediatric medicine. A Nuclear Medicine bone scan is the most effective technique for the early differentiation of bone infection from soft-tissue infection, disorders that are clinically similar, but markedly different in treatment and outcome. A Nuclear Medicine liver excretion study is the only method short of exploratory surgery to differentiate blocked bile ducts from liver inflammation in jaundiced newborn infants, who tolerate surgery very poorly.

Short-lived isotopes available only from DOE facilities permit repeated determination of cardiac function with exercise or administration of drugs, particularly important in pediatrics because children change for better or worse much faster than adults, making speed in diagnosis critical. Isotopes with short half-lives deliver much lower radiation doses to patients.

(F) Aging and Atherosclerosis

Nuclear Medicine provides noninvasive methods of studying changes of brain metabolism during normal aging. Of significance are the initial results of DOE supported research on Alzheimer's disease. A group of collaborating investigators supported in the main by the Department of Energy's high technology program on nuclear instrumentation and the National Institutes of Health have discovered an extremely vital piece of information with regard to Alzheimer's disease. A pattern of decreased glucose metabolism occurs in specific areas of the brain in patients with this disease. These patterns are distinctive, particularly when compared to the patterns seen in normal aged matched individuals as well as individuals with other forms of dementia. If these observations are confirmed, it may be possible, for the first time, to identify patients with Alzheimer's disease. Precise diagnosis of a disease must be possible before effective treatment can be developed.

Atherosclerosis research has benefitted in two major areas. It is now possible using Nuclear Medicine advances in positron emission tomography and single photon tomography to evaluate the efficacy of methods of treatment for stroke and heart attacks. These advances come from developments in instrumentation physics provided through the unique capabilities of the National Labs and from new radiopharmaceuticals. For example, at present, Brookhaven National Laboratory produces the purest form of the tracer Iodine-123 for use in synthesizing compounds to study stroke. The major, and for practical purposes, only source of Strontium-82 which is needed for production of Rubidium-82 used in imaging blood flow of the heart muscle is at Los Alamos National Laboratory. A super high resolution positron emission tomograph which will provide the capabilities for the time to

evaluate metabolic activity in small regions of the brain and heart is being studied by the Department of Energy at Lawrence Berkeley Donner Laboratory.

(G) Mental Disorders

One of the major contributions made through collaborative work between National Labs and Universities, e.g., New York University, Cornell, and Brookhaven, is the investigation of the metabolic patterns of the brain in schizophrenia. This is still an area of great controversy; however, for the first time in centuries, there appears to be a quantitative tool whereby this disorder can be studied in a systematic fashion using noninvasive techniques. Work is also being carried out on studying various receptor systems such as the dopamine and morphine receptors which are involved in a variety of mental disorders.

CONSULTATION WITH DEPARTMENT OF ENERGY

As stated at the outset, we support a continuation of the DOE Nuclear Medicine Applications program for FY 1987 at this year's level of $23.3 million. This is minimal to maintain progress. Nuclear Medicine research is underfunded in relationship to the benefits produced in the past and which can clearly be expected in the future. Some important research facilities are not being maintained. Opportunities are being missed or their realization delayed.

We also want to assure the Committee that the Nuclear Medicine community will continue to work closely with the Department of Energy in the development of its research programs. Judgments on the areas of research most likely to lead to clinical applications five years out are difficult. We stand ready to help this Committee and thek Department of Energy to identify important new directions in diagnostic imaging and therapy. The exchange of views and knowledge between DOE officials and the medical community helps to assure that the greatest possible benefit is derived from the funds committed.

Senator EVANS. Thank you very much, Doctor.

Let me turn first back to Dr. Dean. You mentioned in your testimony to the use of fusion to develop tritium for defense needs.

If we were to expand dramatically in the use of fusion on a worldwide basis, would that also have the problem of potential proliferation in terms of defense of nuclear weapons?

Dr. DEAN. I think the answer is that nuclear weapons still require a fission trigger. The primary concern about proliferation has to do with production of plutonium. Tritium is also required in a thermonuclear weapon. So, a country that could make tritium this way would also have to be able to have a technology for making plutonium in order to be a proliferating problem.

Senator EVANS. Is it easier to make plutonium than tritium now? It is right now, isn't it?

Dr. DEAN. That is right. But the plutonium is the essential ingredient to make an atomic weapon. A country that does not have thermonuclear weapons now would start off making atomic weapons with simple fission bombs.

There would be no incentive, really, for proliferation problems for countries to be developing thermonuclear bombs.

Senator EVANS. Except those already at the fission level.

Dr. DEAN. Eventually.

I think you would have a lead on that.

Senator EVANS. What are the end results of nuclear fusion in terms of the waste products of nuclear fusion?

Dr. DEAN. The fuel cycle, itself, produces helium which is nontoxic and nonradioactive. As far as the fuel cycle, there is no reprocessing of radioactive waste required. In the most popular fuel cycle, joining the tritium neutrons are generated which makes the structure active.

Periodically, if you had to replace a component which would be radioactive, you would have to store that. That is metallic. It is not biologically radioactive material. It is short lived. You would only have to store it for 20 years.

Fusion does not have the long life biologically radioactive wastes that are generated by fission.

Senator EVANS. Do we have an active operation in terms of fusion? If that was a commercial venture right now, would you anticipate that the helium as a byproduct would be collected and utilized?

Dr. DEAN. We would use it ourselves to cool magnets because we use superconductive magnets and we require helium for that.

Senator EVANS. Would there be extra helium beyond that?

Dr. DEAN. There would be extra helium beyond that. We could use it for making transmission lines which is the direction that the industry would go in the future. It does have a value. There is enough of it around now that it is not a valuable product. Helium is present in natural gas sources.

Senator EVANS. We are not likely to get helium, pure helium, any cheaper as a byproduct from nuclear fusion than we do now?

Dr. DEAN. Perhaps in hundreds of years, but I don't think it would be a major factor in the next 100 years.

Senator EVANS. What about the question I asked Dr. Trivelpiece? We are putting a lot of money—I guess you would suggest not

enough money—into nuclear fusion and into some of these exotic, very expensive pieces of research.

Are we overlooking or not spending enough or are we spending in the wrong direction in looking at things that are so complex, so requiring of so much money that we may be overlooking simpler, easier, more straightforward environmentally benign sources of energy, and maybe we ought to put our money, as he mentioned, into understanding and taking from the understanding phase and development and ultimate use of photosynthesis, more practical in terms of ecomomic development of hydrogen and use of hydrogen to replace fossil fuels?

Are we really on the right track?

Dr. DEAN. Supplying our energy for the next 100 years is a trillion-dollar business just to replace the powerplants we have now.

I think the problem is that we are not spending enough money that is commensurate with our energy future, our energy research. It is dismaying to me to see how much of these small research programs and these problems you have talked about have been essentially limited by the Government. I don't think they cost as much as fusion and fission and I think they ought to be maintained.

I do think they have been cut back way below where they should be. I would urge the Congress to try to do something about that. I would hope that that could be done without cutting back further on things like fusion which are inherently somewhat more expensive.

I do think that as the energy budget has come down—you know, in the late seventies the Energy Department budget was about the same as it is now, but in the late seventies about 70 percent of the budget was on civilian energy applications and 30 percent on military things. Now it is vice versa.

I think we have just cut way back on the kind of level on energy research that the country ought to be funding. I think the smaller programs you have mentioned have been hit harder than they deserve.

Senator EVANS. Should we fund a continuing energy research program by a small surcharge on all energy users to make sure we have that continuing source?

Dr. DEAN. I believe so.

Senator EVANS. A fraction of a cent on gasoline, a fraction of a cent on electric generation would probably give us a lot of money.

Dr. DEAN. I think that would be a fair and equitable way to fund research in this country to make the technologies and use of communities that are making a lot of money on these things now and essentially acting in a way that 100 years from now we won't have any more, I think would be a very smart thing to do, to put a small surcharge and put that in our energy technology research trust fund and fund energy research that way.

Senator EVANS. Right now everybody is scrambling to get a piece of the general pie where you have to compete with the military budget, aid to dependent children. To get a separate source, then the scramble would be among the various types of research going on and everybody has his own idea of what is best.

Who should decide?

Dr. DEAN. I haven't thought the whole thing through. I do believe if the Congress were to establish such a fund, the Congress should also establish an agency that would manage that fund that would have fair representation and be accountable to Congress and the board of directors, and so on, so that you could assure no one technology dominated the allocation of the resources.

Senator EVANS. You mentioned specifically the suggestion that we fund to a higher degree than is now being suggested the alternative fusion sources, the mirror methods.

Do you have any views on the relative merits or speed or potential of the various methods that are now being investigated for fusion?

Dr. DEAN. I believe that success speaks for itself. Tokamaks are where they are, not because everyone favored them, but because they work.

Senator EVANS. Is that also true because they got started earlier?

Dr. DEAN. No, I don't think so. In fact tokamaks were invented in the Soviet Union and we were working on mirrors and other things long before we built our first tokamak.

I believe tokamaks can be evolved in such a way that they become better and better every year. That does not mean to say these other concepts can't have breakthroughs, can't come along and ultimately be better. But I do think we ought not to kid ourselves that, you know, the grass is always greener on the other side, and I don't think you should go out and say just because something looks smaller now and perhaps more interesting, but it has not proven itself out, that we should say, well, let us push that and see how it goes.

I think you ought to continue to fund those things and you have to nurse things along and when you have successes, you have to take the next logical step. I don't think you do that by stopping your most successful path or slowing down your most successful path.

You do have to keep pressure on the most successful path to improve its product.

Senator EVANS. I guess that is the point. When you go along in the direction of research, how do you really make a good decision as to when enough is enough, when it appears to be a dead end and it is not worth following or whether it is still promising and deserves to be funded?

We would have hated to have had Edison throw up his hands after the 530th filament that he tried out and when he got to the 600th, he found something that would work.

When do you know? How do you determine that?

Dr. DEAN. I don't usually know. I have been in the program for 24 years and I was in the Department of Energy for a number of those years. I can tell you every time we tried to conclude something was not going to work, some smart scientist would come up with a new idea telling us if you tried it 3 more years, it could work.

That is why you have review committees. Then you have to trust your managers to make a judgment. If the Department of Energy in its wisdom, after all technical reviews, decides to phase out a particular experiment or particular line of effort, I believe we

ought to give them credit for carrying out the responsibilities for which they are paid.

Senator EVANS. If that is the case, are you saying that that is not what they did in terms of the mirror technology?

Dr. DEAN. I am saying in fact if that is what they decide to do within the budget they have, if that is the budget they get, I think we ought to back them on their decision. I think the peer review says that we would like to maintain a mirror program.

If the House of Representatives says if we give you a little more money, would you change your decision, I think the Department would say they would like to retain the small programs if they had more money. If we had more money, I think we ought to maintain the small programs also.

Senator EVANS. So, we are budget limited on some of these things and when we decide to quit something because it appears to be less promising than some other source, although it may still have some promise, but budgetarily we can't do everything, now with the House coming back and saying, it is important, we would like to throw $30 million more at you, it is obvious the Department of Energy will say if you are going to throw it at us, we will catch it.

Is there not another decision to make at this point and not say, OK, $30 million more and it is for magnetic or for mirror fusion?

If we are budget constrained in this, we are budget constrained in a whole lot of energy research areas. Should we not say if you are going to give us $30 million more, here is where the $30 million ought to go, not in this one specific area that you happen to be interested in or Members of the House put it forward for, but say that is not the way to spend your money if in fact it isn't?

Maybe it is in nuclear medicine. We may have dissenting views here as to where $30 million might go for the benefit of the country.

Dr. DEAN. I can't really comment on that. I can only say that within the fusion advisory group they would like to maintain a mirror program as part of the U.S. effort. The House of Representatives agrees with that and they would like to provide money. They have to balance all these things also and have to balance aginst the water projects and still come up with that money.

I applaud them for it. I hope you will agree that this $25 million will be well spent. If you in your wisdom decide you have other things to cover, I respect your judgment also.

Senator EVANS. I have heard it said we ought to pay attention to the scientists and review panels and people in the Department of Energy and managers for these kinds of priorities.

Dr. DEAN. Once they know what their budget is, I believe we should do that.

Senator EVANS. If they have $30 million in the budget, should we not allow them to review the situation to see where they want to spend it?

Dr. DEAN. I believe you should allow them to distribute it on those programs that in their judgment the money should go to. I don't believe you should tell them what program the money should go to.

Senator EVANS. In that process we should have the response from them. Otherwise they will be obligated to spend it on this particular piece of research because that is the basis on which the extra money was given to them, but the Members of Congress and House of Representatives who put this money in put it in without having the benefit of another set of recommendations from the Department.

Dr. DEAN. They did have available to them a result of the peer review that the Department carried out in the past few months. They did have available to them the recommendations of the fusion advisory committee which are very consistent with the records in the House report. I believe that the Department feels very comfortable with both.

Senator EVANS. That has to do with the potential in the field and the worth and value of this particular element of magnetic fusion research. I don't think any of those bodies have dealt with the question of whether $30 million more would be better spent in some other one of the broad non-fusion-oriented elements of research, many of which have been cut back.

Dr. DEAN. That is true. I can't really comment. I think that the Department of Energy has not asked for this money is what you are saying and, therefore, they have not said if they could have $30 million, what they would do with it. No one has given that option and I know of no case where the Appropriations Committee has given them that option. I am not sure they have had that option.

Senator EVANS. I think it is appropriate to ask the question. If the answer remains the same, then that is fine, that is what we should do.

Dr. DEAN. I would hope your committee would find ways to add more money to a lot more energy programs and we are not just dealing with $30 million.

Senator EVANS. Let me turn to nuclear medicine.

To what degree is the research on nuclear medicine, things that are going on? The first question is: How is that money actually utilized in research?

Is it further transferred from the Department to various universities and similar labs for conducting that research? Is a good share of it done through and directed by the Department of Energy?

Dr. DWORKIN. Most of that is competitive, grants of one sort or another to labs supported by DOE and universities. These labs carry out the research on the basis of program grant requests.

Senator EVANS. Are you satisfied with the interchange of information that comes from the separate, I would guess sometimes pretty comparable pieces of research? Is there good exchange of information so that we get maximum benefits out of the separate pieces of research?

Dr. DWORKIN. I think the ordinary system that has been used in the medical field is publishing referee papers, presenting material at scientific meetings similar to the one going on in Washington now. This seems to be a pretty good method of disseminating such information usually on a referred basis so that the quality of the work is kept at the optimum.

Senator EVANS. Do we have any good system—I notice in a lot of other fields of research and gathering of information that we some-

times develop more good information than we are able to catalog and easily transfer from one person to another.

We find in too many instances sort of duplicating efforts being carried out without the knowledge of the several parties carrying out that research.

In your field, in the nuclear medicine field, is there some good way of exchanging information beyond just what you have mentioned which I understand is a traditional and normal way to do it?

It seems to me we are getting to the point where information development, research development is so broad and so fast, it is almost exploding, that it is difficult to ensure that any one researcher has access to information about the same kind of research going on somewhere else.

Have we tried to develop any kind of center or exchange or even, I suppose, a computerized way of collecting and disseminating information?

Dr. DWORKIN. I think it is a possibility because there is a good deal of information accumulating. However, most of these programs that I have alluded to and that we have requested funding for are long-term programs.

In other words, the temporal delay between the time of putting in the grant request and completing the research is fairly long and that information has some time during that period to travel between various centers. And it is a small group that does this research. There aren't dozens and dozens of centers.

The number of centers are few and they are small clubs in a way in that very few places have facilities to carry out the sophisticated kinds of research that is required. Although the risk exists, I don't think it is too likley there will be many institutions that are carrying on similar work. Nonetheless, some duplication is required for verification.

Senator EVANS. That is almost deliberate duplication or at least desirable?

Dr. DWORKIN. It is desirable.

Senator EVANS. You say it is a small club.

Are we at the point where the club ought to be expanded?

Dr. DWORKIN. The doors of the club are not closed. Anyone who feels that they have a capablility for competing for such grant requests may certainly do so.

Senator EVANS. Is the initiation fee too high for them to get in? What do they have to have before they are really looked on as competitors?

Dr. DWORKIN. They have to have some facilities, they have to have some physical facilities, they have to have the manpower, and this is built up slowly over a period of time.

There are several labs in the United States, however, that have these facilities and certainly deserve support.

Senator EVANS. At what point does the research get translated into the kind of equipment, the kind of actual patient-oriented activities and is that portion of this whole continuum adequate?

Do we have the people who will pick up on the research and translate it into the kind of equipment and processes that are useful for patients?

Dr. DWORKIN. Can I ask Dr. Wolf to address that? He runs such a lab and perhaps he can address that better than I can.

Senator EVANS. Please. Identify yourself for the record.

Dr. WOLF. My name is Alfred P. Wolf, chairman of the chemistry department at the Brookhaven National Laboratory.

Senator, I think there are many examples of this transfer. Perhaps a good example is the one that Dr. Dworkin brought up, namely, positron emission tomography.

In 1976 all this work was being done in the United States. There were only two companies which provided synchrotrons. There were no companies at that time which provided positron emission tomographs.

In this year there are 60 laboratories worldwide that have picked up this technology. There are now five companies that produce synchrotrons. There are approximately five companies that are in the positron tomograph field. These depend on the high technology of labs that have the wherewithal to do this research. They depend on this technology in order to expand this.

So, there is no question that the kind of high technology that the Department of Energy supports is translated into industry.

I would like to address a question that you asked, namely, how do people communicate?

In this area the communication is excellent. We have phone lines. We talk to each other constantly so that unnecessary duplication is usually avoided in this field.

Senator EVANS. We thank you all for your testimony in two fascinating fields. I think we all wish that we could do what was necessary to move as rapidly as research will allow us to move.

I think that probably I won't even ask the question, but I suspect all of you agree that research by its nature is sequential, as Dr. Trivelpiece said of Newton, that you can't just throw money at basic research and expect answers promptly. You build on what each one discovers and how that leads to the next discovery, trying to get some of that built into some of the other things we are trying to do in military research right now.

Thank you very much for your testimony and I think that ends the panel.

The hearing is adjourned.

Dr. DWORKIN. Thank you.

[Whereupon, at 4:15 p.m., the hearing was adjourned.]

Appendix VI

Responses to Additional Committee Questions

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

JUNE 23, 1986 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

WITNESS: MARY L. WALKER

QUESTIONS SUBMITTED BY: SENATOR ~~DOMENICI~~ Domenici

SET I

Questions from Senator Domenici

Question 1): Since your Office was established, has there been any changes in DOE policy or line management with respect to meeting Federal standards for environment, safety and health?

Answer: Yes, there have been several changes in DOE policy related to environment, safety and health matters since my Office was established. The Secretary's Environmental Policy Statement of January 1986 reinforces the Department's commitment to comply with applicable legal requirements. In addition, it focuses on adherence to the spirit as well as the letter of applicable statutes, regulations, and standards; a commitment to risk minimization; and consistency across all DOE operations in meeting our environmental obligations. We have established an interim policy on State regulation of radioactive mixed waste that is designed to facilitate resolution of mixed waste issues. In addition, where DOE determines that it is necessary to send hazardous waste off-site for treatment, storage, and disposal it is now DOE policy to send such waste to facilities which have been identified by EPA or state regulatory agencies as suitable.

Line management responsibility for conducting its activities in accordance with applicable statutes, regulations, standards, and internal policies has not changed, but rather has been underscored by our recent initiatives. The steps taken to strengthen the DOE headquarters ES&H programs will serve to provide line management with increased technical support and more consistent policy guidance, and the Department with a more credible oversight and validation program in the area of ES&H performance.

Questions from Senator Domenici

Question 2: How strict are DOE's nuclear safety standards in comparison to NRC°s regulations?

Answer: DOE standards are fully comparable to those used by the NRC. The basic Order that established the Department's Environment, Safety, and Health Program states that DOE's nuclear facilities will be sited, designed, constructed, modified, operated, maintained, and decommissioned in accordance with the standards, guides, and codes that are applied to comparable licensed facilities.

Questions from Senator Domenici

Question 2B: How strict are DOE's environmental standards in comparison to EPA's

Answer: In regard to non-radiological pollutants, DOE and NRC licensee facilities are subject to the same environmental laws and regulations whether at the Federal (EPA) or State level, and therefore, there are no differences in standards and requirements that DOE and private commercial facilities must meet. Compliance with such standards is set forth in DOE Orders, in which the Department's environmental standards are embodied. In addition to providing verification to State and EPA authorities, through permit documentation, monitoring reports, and regulatory notifications, the Department provides compliance oversight through its field operations offices and its Headquarters Office of Environment, Safety and Health. With respect to hazardous waste management, the management of waste consisting solely of "source, special nuclear, or byproduct material," as defined by the Atomic Energy Act, is exempt from RCRA as provided in Section 1004(27). Requirements for the management of this waste are set forth in DOE Orders and consistent with industry practice, as defined by national standards organizations (NRC and EPA). For "mixed" hazardous and radioactive waste, DOE has been working closely

with EPA and the States on a case-by-case basis to determine how the requirements of RCRA will be applied to DOE facilities that generate such waste. These efforts are consistent with DOE's Interim Policy on state regulations of "Mixed Waste," dated March 31, 1986. A June 4, 1986, Agreement in Principle with EPA and the State of Colorado establishes that RCRA will apply, with joint DOE/EPA review if inconsistencies between RCRA and the Atomic Energy ACT arise. Under the Clean Air Act, DOE facilities are required to meet air emission standards for both non-radiological and radiological pollutants. The Department has been working closely with EPA to define the applicability of the latter requirements under the Clean Air Act's National Emission Standards for Hazardous Air Pollutants (NESHAPS).

Questions from Senator Dominici

Question 3: GAO's June 1986 report (GAO/RCED-86-175) identified three defense facilities that did not have approved safety analysis reviews (Rocky Flats and Savannah River facilities). The report also identified inconsistencies in the degree of detail contained in the SARs for various facilities, and criticized the DOE for not obtaining independent reviews of its SARs. What is your Office doing to correct these deficiencies?

Answer: The Safety Analysis Report process is being reviewed and those nuclear facilities for which SARs have not been approved by DOE are receiving priority attention.

No DOE nuclear facility has ever operated without benefit of an approved safety assessment. In 1976, the Department recognized the benefits of using consistent format and guidance to prepare safety assessments and a new program was established to prepare new safety assessment documents for existing major nuclear facilities. These safety documents were called Safety Analysis Reports which have a standard format and use uniform guidance in their preparation. Therefore, there should not be inconsistencies in the degree of detail in the Safety Analysis Reports. We are reviewing those noted in the GAO report and, if there are significant inconsistencies, we will correct the problem.

Last year the Secretary instituted several initiatives to establish a strong, independent oversight organization within the Department. As a result of this initiative, the Assistant Secretary for Environment, Safety and Health, who is fully independent of any operating responsibility for nuclear facilities, must concur in the initial construction and startup of all DOE reactors and high and selected moderate hazard facilities. Significant modifications to existing facilities will be subjected to the same independent

review process. The SARs are one of the most important bases for these decisions.

In addition, the Department has had an SAR review process for several years which includes reviews which are independent of the line operating organizations at the contractor and field office level. We are considering what additional review action, if any, should be taken on existing facilities.

We believe that the existing DOE system, plus the planned improvements described above, provide an adequate safety analysis review process.

QUESTIONS FROM SENATOR DOMENICI

Question #4: Please provide to the Committee a complete breakdown of the specific activities under line item "Environmental Audit and Compliance" that account for the $26.5 M increase in funding level. Will this work be accomplished primarily by contractors? Does any of this money go towards the purchase of computer capabilities? If so, how much?

Answer: The Environmental Audit and Compliance Program was initiated in FY 1986 as a principal element of the Secretary's plan to strengthen the Department's Environment, Safety and Health programs. The goal of the program is to ensure that the Department's operating facilities are in compliance with all applicable environmental requirements and to reduce areas of existing environmental risk. This will be accomplished through a number of activities. These activities include the one-time baseline "Environmental Survey", a continuing program of environmental audits, and continuing support and oversight to Field and Program offices on environmental compliance issues.

The one-time baseline Environmental Survey, which is to be followed by a continuing program of regular environmental audits of all operating facilities, began in FY 1986 utilizing existing Departmental resources and will take about 2 1/2 years to complete. Survey activities include: 1) on-site activities, i.e., observation of operations, reviews of records and documents, interviews with

facility personnel, and a complete study of the environmental conditions at a site; 2) sampling and analysis; and, 3) a prioritization of identified problems. The Survey covers all areas of environmental regulation, including air pollution, water pollution, soil contamination, and hazardous waste management. The Environmental Survey is being conducted by multi-disciplinary teams of specialists led and managed by DOE ES&H personnel. Each team is being supplemented and supported by technical experts through a contractual effort. The sampling and analysis teams will be supported through contracts with the National Laboratories.

In FY 1986, the planning and preparatory work for the Environmental Survey was completed. This included analysis of existing site information, development of an implementation plan and detailed schedule, development of survey procedures and protocols, development of sampling procedures, and development of risk assessment methodologies and prioritization criteria. In addition, it is anticipated that the on-site work for the surveys for the Feed Materials Production Center, the Portsmouth Gaseous Diffusion Plant, the Rocky Flats Plant, and the Hanford Site will be completed in FY 1986.

The FY 1987 budget request for the Environmental Survey is $30 million, of which $28 million will be used for sampling and analysis. In FY 1987, it is expected that the survey of 20 DOE facilities will be completed. These facilities include: the Oak Ridge Site; the Paducah Gaseous Diffusion Plant; the Pantex Plant; the Savannah River Plant; the Livermore Site; the Kansas City Plant; Brookhaven National Laboratory; the Pinellas Plant; the Knolls and Kesselring Sites; Los Alamos National Laboratory; the Nevada Test Site; Fermi National Accelerator Laboratory; Morgantown Energy Technology Center; Idaho National Engineering Laboratory; Sandia National Laboratory; the Component Development and Integration Facility; Argonne National Laboratory; Pittsburgh Energy Technology Center; Bettis Atomic Power Laboratory; and the Lawrence Berkley Laboratory.

The program of continuing support and oversight has been developed to provide DOE Field and Program offices with: technical support and assistance in resolving problems associated with environmental permitting; technical reviews of environmental control and remedial action projects; and coordination of the resolution of Department-wide environmental compliance issues to assure that the

Department's operations are conducted in a uniform and consistent manner. In addition, support will be provided to the annual ES&H effort to prioritize environmental projects to implement suggested corrective actions.

The FY 1987 budget request for the continuing support and oversight portion of the Environmental Audit and Compliance program is $4 million. This effort will be conducted with technical assistance provided through a contractual effort.

FY 1987 money for the Environmental Survey will not be used to purchase computer capabilities. It should be noted, however, that ES&H is developing a Computer Assisted Tracking System (CATS) which was one of the Secretary's initiatives. This system will provide the capability to track environmental permits, technical safety appraisals, environmental Survey recommendations, corrective actions, etc. The data obtained from these and other ES&H activities will be included in the System. Monies for the CATS will come from funding for program direction and capital equipment in an amount of approximately $450,000.

Questions from Senator Johnston

GAO Report on Safety Reviews

Existing Review

Question 1: Why is it taking so long to complete the safety reviews at these three facilities?

Answer: The preparation of Safety Analysis Reports to replace prior safety assessments of existing facilities has received a lower priority than the analysis and preparation of SARs for new facilities. Most of the existing nuclear facilities now have DOE-approved SARs and we plan to expedite approval of those not yet completed.

Question 2: What other facilities have uncompleted safety reviews?

Answer: The following high hazard nuclear facilities are being reassessed and the target dates for their corresponding review/approval are shown below:

	Facility	Target Date
1.	Plutonium Fabrications,* Rocky Flats, CO	July 1987
2.	Plutonium Recovery, Rocky Flats, CO	July 1987
3.	Plutonium Manufacturing, Rocky Flats, CO	July 1987
4.	Reprocessing,* Savannah River, SC	October 1986
5.	Fuel Fabrications,* Savannah River, SC	September 1986
6.	Plutonium Processing, Savannah River, SC	November 1986
7.	Receiving Basin for Offsite Fuel, Savannah River, SC	September 1987
8.	Tritium Facilities, Savannah River, SC	February 1987

* These facilities were identified in the GAO Report.

Question 3: What are you doing to develop a coherent safety review process?

Answer: One of the major objectives of the Secretary's new initiatives is to improve consistency in the implementation of the Department's overall ES&H program. In order to assure that this takes place, the Secretary has established a Headquarters Office of Environment, Safety and Health which reports to him and provides the central focal point for the Department's safety oversight. The safety analysis and review process, which is one part of the overall ES&H program, will be significantly enhanced by elevating and requiring the review and concurrence by the Assistant Seretary for Environment, Safety, and Health on Safety Analysis Reports for all new reactor and high hazard nuclear facilities, and selected moderate hazard facilities. Review and concurrence on significant modifications to existing facilities will also be required. These mandatory reviews and concurrences by the Headquarters ES&H organization will assure that DOE facilities are consistently evaluated and compared against DOE design criteria and that uniform approaches and assumptions are utilized in the accident analyses described in the SARs. Concurrently, updated and improved guidance for safety analysis is being provided which will be appropriately incorporated into the DOE Orders. Also, the Department requirments for nonreactor nuclear facilities' SARs have recently been updated to formally require utilization of appropriate NRC standard format and content guidelines. This requirement has been in place for some time for DOE nuclear reactors. In addition, the Secretary's new initiatives include Technical Safety Appraisals of DOE's major nuclear facilities. To carry this out, ES&H will perform

multidisciplinary on-the-spot appraisals of over 50 nuclear facilities to determine their compliance with DOE's safety requirements and how well they have taken into account the implications of the lessons learned in the nuclear industry and licensed facility requirements.

Question 4: How is public comment incorporated in this development?

Answer: DOE provides an opportunity for public comment on operating and proposed facilities through its field offices and through the NEPA process for new projects and major changes. One example of field office/state/public interaction is the review of the Rocky Flats Plant. The DOE interfaced with a committee established in 1981 by Governor Lamm and Congressman Wirth--the Blue Ribbon Citizens Committee (BRCC) on the safety of the Rocky Flats Plant. DOE provided briefings, tours, and safety reports to a State of Colorado citizens committee consisting of prominent lawyers, physicians, educators, and representatives of consumer groups. DOE interacted with the BRCC for several years and a final report was issued by Governor Lamm which provided health and safety and other recommendations to DOE. In general, DOE uses the NEPA process as a mechanism to obtain public comments on environmental and safety concerns. Normal operation and accident evaluation are assessed. The EIS provides an excellent forum to debate the issues since it is looking at the effect that proposed operations will have on man and the environment.

Question 5: How is this process related to the "Technical Safety Reviews" you talked about at your confirmation hearing?

Answer: Safety and "safe" operations really mean the management of risk so that its existence is reduced to an acceptable level. The management of risk involves a combination of good safety practices, a sharing of experience, and effective independent review by ES&H. The Department's nuclear facilities are operated under a strong and effective regulatory program which provides a multi-tiered, time-phased approach to safety.

Safety begins at the conceptual design of a facility because it is impossible to build safety into an inherently unsafe system. The Department's safety program starts with the clear assignment of responsibility for safety to DOE and contractor line managers in Headquarters and the field. In the very early stages of the project, preliminary Safety Analysis Reports are developed to support further design work.

As the design matures, this leads to the final Safety Analysis Report. In September 1986, Secretary Herrington directed the implementation of a series of initiatives that resulted in the formation of an independent oversight organization that now has responsibility to review, in the early stages of a project, the safety of the design. Upon approval of design, the independent oversight organization provides quality assurance overview to assure that the system is operating in a manner that will provide a high confidence that the facility is actually built in accordance with the design that was approved in the Safety Analysis Report.

After a facility has become operational, it is subject to a series of appraisals conducted by experts in varying disciplines to assure that the managers and employees fully adhere to safe practices. In practicing an abundance of caution, the Secretary ordered a series of additional appraisals, termed Technical Safety Appraisals, to be performed at all high and selected moderate hazard nuclear facilities. These appraisals are multidisciplinary and cover such activities as organization and administration, maintenance, training, emergency preparedness, technical support, security, facility safety, radiological and fire protection. In addition to the above appraisal procedures, all unusual occurrences, even if they are not safety related, are reported to the independent oversight organization for analysis and for dissemination to other parts of the Department complex for review and analysis.

Thus, the Technical Safety Appraisal is one part of a process to assure that the risks involved in operating our nuclear facilities are acceptably small. The combination of good safety practices, a sharing of experience and effective independent review by the Department's independent oversight organization provides the basis for strength and confidence in the Department's management of risk.

Credibility

Question 6: Why shouldn't these safety analyses be subject to truly independent review that includes people other than DOE employees or contractors?

Answer: Under Secretary Herrington's initiatives, an independent organization has been established to overview the Department's activities. This overview is in addition to the review process that is exercised by the Congress through its appropriations and oversight functions.

DOE has a variety of missions including research, development, and production. This diversity of function requires a dedicated cadre of personnel to oversee a complex having truly unique facilities. The Department has expertise that is unique and is frequently called upon to support national and international bodies in developing rules and standards. An additional layer of oversight, which is competent and educated, will therefore be hard to find and costly to develop and implement. We do not believe that DOE's strong safety performance makes this additional burden necessary.

Question 7: How are the affected States and the public included in the present review process?

Answer: The most direct involvement is through the NEPA process. Also, unclassified Safety Analysis Reports, accident investigations, and unusual occurrence reports are all readily available to the public. In addition, field office personnel interact on many levels with county and state officials to keep them apprised of activities at their sites. This interaction is illustrated by the Rocky Flats Plant interaction with local officials described earlier.

Question 8: If a truly independent review were to be undertaken, what would be the best forum? Current practice? Hearings held locally? A hearing at DOE? A hearing at the NRC? A study by someone like the National Academy of Sciences? Explain your reasons for your choice.

Answer: Since the purpose of an independent review is to obtain the best technical assessment of a problem by personnel having no vested interest in the outcome of the assessment, we believe that the current practice of the Department is the best forum. The Department has instituted an independent review process that has at its disposal thousands of manyears of nuclear experience that an outside forum would be hard pressed to match.

Question 9: Isn't the system we are now using to regulate DOE nuclear facilities--self-regulation--essentially the same as the system that is supposed to insure safety--and doesn't--in the Soviet Union? What are the differences?

Answer: We are not familiar with the system used by the Soviet Union and cannot comment on it. DOE's safety system is a multi-tiered process: (1) the contractor, (2) the field office, and (3) the Headquarters line organization with an independent review by the Assistant Secretary for Environment, Safety and Health provides an effective check and balance system. Our nuclear safety record bears this out. Moreover, the DOE's operating contractors have an incentive to operate DOE's nuclear facilities in an environmentally and safe manner. In contracts with an award fee, if the contractors don't perform satisfactorily, the contractor could fail to receive a substantial amount of award fee. In other situations, the contract could be terminated.

Furthermore, the Department's system is based on the use of national and international standards. The adoption of these standards incorporates public participation which, as far as we know, is not practiced in the Soviet Union.

N Reactor

Question 10: What are your plans to make your review of the N Reactor available for public comment?

Answer: Three reviews of the N Reactor involving this Office are in progress or completed. The results of all of them are or will be made available to the public. A special safety review was initiated on May 5 to consider two specific issues that were believed to have figured importantly in that accident--fire protection and graphite and the confinement system. The resulting report was released to the public on May 19, 1986. The second review was a comprehensive Technical Safety Appraisal that originally was to have begun in December 1986 and was rescheduled and began on May 19. The report of that review was released July 17, 1986. The third review, a Design Review, also began on May 19. This review is still underway and is expected to be released by early August.

Question 11: Please describe the three most severe design basis accidents that you are looking at in analyzing the safety of the N Reactor. Are any of these accidents as severe as the one that caused the release at Chernobyl, or is that accident deemed "incredible" at the N Reactor?

Answer: The most severe design basis accident considered in the Safety Analysis Report for the N Reactor is a rupture of a pressure tube. In addition, a very severe or "maximum" break of the 24-inch inlet manifold coupled with failure of the emergency core cooling system was hypothesized in the Safety Analysis Report and shown to be able to be accommodated by the confinement system. Many other severe accidents are being considered in the design review, and some of the recommendations coming out of the review will undoubtedly be related to such accidents.

Full details of the Chernobyl accident are not yet available. Nevertheless, the design review of the N Reactor has established that there are significant differences in the way the nuclear plants are designed, and these lead to significant differences in characteristics of operation and of performance in accident situations. These are sources of important safety features of the N Reactor. These design features have convinced the design review group that, while most of the specific features of the Chernobyl accident are still not revealed, the N Reactor does not have the design features that are associated with the Chernobyl accident.

Question 12: How does the current N Reactor review relate to the safety analysis approved in 1978? Describe any plans you have to update this analysis based on information accumulated since 1978 (Three Mile Island data, for instance).

Answer: The 1978 safety analysis provided the starting point for the current N Reactor design review. The current review also considered the many upgrading actions which have been made at that facility to enhance safety since the 1978 safety analysis. There have also been upgrades based on post-TMI "lessons learned." The design review report will analyze the implementation of lessons learned from the Three Mile Island accident. Although additional safety analyses are currently in progress, and more will likely be recommended, we don't expect that the 1978 Safety Analysis Report will need to be updated. Rather, it will be supplanted by a probabilistic risk assessment which has been initiated.

FERNALD

Question 13: At your confirmation hearing in December 1985, you told us that DOE was assessing off-site contamination at the Fernald Feed Materials Production Center.

Answer: (a) What have you found?

Studies have been conducted to assess in detail any off-site contamination resulting from the FMPC's operations. These studies were prepared to support DOE's legal activities related to ongoing litigation. A copy of the interim report on these studies is enclosed.

(b) When will your results be made public?

The results of the off-site studies are currently available to the public.

(c) What actions have been taken to restore public confidence in DOE management at Fernald? What actions are planned?

Efforts are underway to improve the FMPC's environmental, safety, and health performance, and to correct specific deficiencies at the FMPC. The aggressive corrective action program includes the implementation of a comprehensive air pollution control program, including installation of new bags in bag houses, new improved filters, additional alarm systems, and an improved monitoring program that includes better sampling locations and two new off-site monitoring stations. Recommendations to initially control contaminated surface runoff are

being implemented and other recommended actions are under evaluation. DOE is also finalizing its draft Environmental, Safety and Health Management Plan. The 5-year plan is designed to provide a comprehensive program that identifies environmental management, health and safety improvement areas. The plan will also include proposed projects for improvements in environmental, health and safety management and emergency preparedness.

It is anticipated that FMPC operations will improve under DOE's new contractor (Westinghouse). Westinghouse has extensive environmental experience and a commitment to improving the environmental performance of the FMPC. The DOE Operations Office has held public meetings in order to communicate the positive steps that the Department is taking to correct past problems and avoid new ones. Reading room material at the FMPC and public library is being expanded and a new and larger reading room at the FMPC is under design. FMPC and DOE personnel are also working with local and State officials to improve procedures, coordination, and training for emergency preparedness. In addition, DOE will be preparing an Environmental Impact Statement (EIS) for renovation and waste management activities at the FMPC.

A Federal Facilities Compliance Agreement (FFCA) was signed by DOE and Region V, U. S. Environmental Protection Agency (EPA) for the FMPC on July 19, 1986. The FFCA commits DOE to undertake actions to attain compliance with all environmental statutes. The FFCA also describes responsibilities and involvement of DOE, U. S. EPA, and Ohio EPA in activities under the FFCA. The Agreement only covers compliance with environmental laws and regulations over which EPA exercises primary jurisdiction. DOE is also negotiating a consent decree with the State of Ohio. The consent decree has been developed to resolve the civil lawsuit filed by the State in March 1986. The consent decree will also commit the DOE to actions to attain compliance with environmental laws. In addition to these efforts with EPA and the State, DOE is currently working with the State and local agencies to implement independent off-site monitoring programs.

Attachment Question 13

INTERNATIONAL TECHNOLOGY CORPORATION

RESPONSIVE TO THE NEEDS OF ENVIRONMENTAL MANAGEMENT

INTERIM REPORT
AIR, SOIL, WATER, AND HEALTH RISK ASSESSMENT
IN THE VICINITY OF THE FMPC
FERNALD, OHIO

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

JUNE 23, 1986 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

WITNESS: MARY L. WALKER

QUESTIONS SUBMITTED BY: SENATOR ~~DOMENICI~~ McClure

SET II

Questions from Senator ~~Domenici~~ McClure

Question: One of your stated goals is to "assure that national environmental protection goals are incorporated into the formulation and implementation of energy policy and programs."

Question 1a: What are these "national environmental goals"?

Answer: This ASEH goal reflects one of the congressional declarations of purpose contained in Section 7112 of the Department of Energy Organizational Act of 1977. National environmental goals are contained in a series of legislation enacted by the Congress since 1970. To the extent that the 19 statutes that were identified in the FY 87 budget submission contain explicit goals, and policy statements, we view the totality of these legislative statements as the national environmental goals. For example:

- The National Environmental Policy Act declares a national policy to encourage productive and enjoyable harmony between man and his environment; to prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological system and natural resources important to the nation; and to establish a Council of Environmental Quality.

- o The Clean Water Act declares, in part, that its objective is to restore and maintain the chemical, physical, and biological integrity of the nation's waters and that it is the national goal that:
  - The discharge of pollutants into navigable waters be eliminated by 1985.
  - Wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shell fish, and wildlife and provides for recreation in and on water be achieved by July 1, 1983
- o The Clean Air Act states, in part, that its purposes are to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population.

Question 1b: What policies and procedures have you implemented to achieve these goals for other DOE programs?

Answer: As part of the initiative to strengthen and upgrade DOE environmental programs, the Secretary issued a statement of environmental policy for the Department in January 1986. The Secretary's statement reinforces the Department's commitment to comply with applicable legal requirements. In addition, it focuses on adherence to the spirit as well as the letter of applicable statutes, regulations, and standards; a commitment to risk minimization; and consistency across all DOE operations in meeting our environmental obligations. An environmental issue coordination process has been implemented to assure that consistency of approach. We have established an interim policy on State regulation of radioactive mixed waste that is designed to facilitate resolution of mixed waste issues. In addition, where DOE determines that it is necessary to send hazardous waste off-site for treatment, storage, and disposal it is now DOE policy to send such waste to facilities which have been identified by EPA or state regulatory agencies as suitable.

As part of the effort to update and revise the series of ES&H internal directives, six safety Orders will be reissued in FY 86. In FY 87 we expect to issue major revisions to the DOE orders covering General Environmental

Protection Requirements, Public Radiation Protection Standards, Hazardous and Radioactive Mixed Wastes, and a manual of mandatory environmental radiation monitoring requirements.

Questions from Senator Deomenici

Question 2: What environmental laws and regulations are applicable to Departmental activities?

Answer: The DOE must comply with environmental laws and implementing regulations to the same extent as other Federal agencies, insofar as these requirements apply to its activities. Major examples of such laws are listed below:

- National Environmental Policy Act
- Resource Conservation and Recovery Act (RCRA)
- Clean Water Act (CWA)
- Endangered Species Act
- Fish and Wildlife Coordination Act
- Hazardous Materials Transportation Act
- Safe Drinking Water Act
- National Historic Preservation Act
- Comprehensive Environmental Response, Compensation, and Liability Act
- Coastal Zone Management Act
- Clean Air Act
- Toxic Substances Control Act (TSCA)

However, it should be noted that several of those statutes, i.e., RCRA, TSCA, and the CWA, exclude from regulation, source, byproduct, and special nuclear material, which are regulated under the authority of the Atomic Energy Act.

Questions from Senator Domenici

Question 3: What are the Department's policies and procedures to assure conformance with applicable environmental laws and regulations?

It has been the policy of the Department to comply with applicable environmental laws and regulations. That policy has been restated forcefully in Secretary Herrington's environmental policy statement of January 1986. Additionally, the Secretary's statement focuses on adherence to the spirit as well as the letter of applicable statutes, regulations, and standards; a commitment to risk minimization; and consistency across all DOE operations in meeting our environmental obligations.

The Secretary's new initiatives have resulted in the implementation of a compliance assurance program consisting of two major elements:

- An enhanced effort to provide guidance, direction, and mandatory requirements to all DOE programs so that environmental responsibilities are well understood, and

- An enhanced oversight activity that includes comprehensive surveys of all major facilities to identify and confirm environmental deficiencies, special audits to verify compliance, and an issues coordination process.

Headquarters guidance is implemented through the DOE directives system which includes a series of Orders dealing with environmental protection. Specific subjects of these environmental directives include: general program requirements, radiation protection, hazardous and radioactive mixed wastes, inactive waste sites, appraisals, and reporting. Major revisions will be issued for the more critical Environmental Orders in FY 87. Pending their issuance, the Office of Environment, Safety and Health will prepare interim guidance where required. For example, we recently established an interim DOE policy on anticipated state regulation of radioactive mixed waste. In addition, where DOE determines that is is necessary to send hazardous waste off-site for treatment, storage, or disposal, it is now DOE policy to send such wastes to facilities which have been identified by EPA or state regulatory agencies as suitable.

The goal of the strengthened oversight program is to ensure that DOE operations comply with every applicable environmental requirement and to reduce areas of environmental risk. It will be accomplished through a one-time baseline environmental survey program that will identify, confirm and prioritize

environmental problems at all major DOE facilities. Each environmental survey will be conducted by a DOE ES&H-led, multi-disciplinary technical team. Additionally, a continuing program of regular environmental audits designed specifically to verify compliance will be conducted as a follow-on to the survey program. Finally, the ES&H headquarters staff will be directly involved in oversight of compliance issues and specific permit requirements with regulatory agencies. In support of this element of oversight, procedures on the coordination of environmental issues that affect the Department were recently issued.

Question 4: A new initiative in Environment, Safety and Health involves a baseline Environmental Survey of all DOE facilities.

a. What prompted this initiative?

Answer: The purpose of the Survey is to identify and then prioritize, DOE-wide, the areas of existing environmental problems and risk. This is a one time, "no fault," baseline Survey of the major DOE facilities. The results of the Survey will enable the Department to develop, on a uniform basis, comprehensive, long-range plans for correcting any identified problems and reducing environmental risks. Since the Survey is supplementary to ongoing environmental projects and corrective action, funding for it is not intended to displace such efforts.

b. What are its specifics?

Answer: The key specifics on the Environmental Survey are:

- The Environmental Survey covers all media (air, water and soil) and all areas of environmental regulation. The survey also covers all DOE programs and major operating facilities: the facilities are grouped into about 40 DOE sites at which there are an estimated 600 inactive waste areas, 300 hazardous waste management areas, 1800 air emission stacks, and 400 water discharge pipes.

- The Environmental Survey began in June 1986 at the Feed Materials Production Center, in Fernald, Ohio. Reviews of operations at four other locations, Mound and Portsmouth in Ohio; Rocky Flats in Colorado; and Hanford in Washington will follow in August. The survey of all sites will be completed by late 1988.

- The Survey will be conducted by five teams led by personnel from DOE's Headquarter's Office of Environment, Safety and Health. NUS Corporation, as contractor to this DOE office, will provide five to ten technical specialists for each team.

- A typical team will include environmental engineers, environmental protection specialists, physical scientists, chemists, hydrogeologists, and specialists in environmental protection, water resources, radiation monitoring, and hazardous waste management, as well as a representative from the involved DOE Operations Office. Each team will have a core group that will stay together for the entire Survey to maintain continuity and consistency.

- The Survey will include observations of operations, collection and review of records and documents, personnel interviews, study of

the site's overall environmental status and sampling. Sampling and related testing and analysis will be conducted by DOE National laboratories in accordance with appropriate methods and procedures.

- o DOE will work closely with EPA and state regulatory agencies to address their concerns about potential environmental problems.

c. What corrective actions will be considered or implemented before the Surveys are completed?

Answer: The Survey is intended to complement rather than preempt or disrupt ongoing environmental programs at the sites. It is expected that the Survey will assist the sites in focusing their environmental programs. The surveys will provide an framework for the sites to view their environmental status. While the formal conclusion of the survey process is approximately 2 1/2 years hence, initial responses to survey findings are expected to have beneficial effects on environmental programs. Many operational or procedural problems will likely be identified that lend themselves to relatively straightforward correction without the need for sampling and analysis results.

Question 5: You stated that a baseline Environmental Survey at the Feed Material Production Center in Fernald, Ohio, has begun.

a. What are the objectives of this Survey?

Answer: The objective of the Survey is to identify environmental problems at this DOE facility. After surveys at the major DOE facilities are completed, a Department-wide prioritization of environmental problems will be developed.

b. Who are the members of the Survey team?

Answer: The Survey Team Leader and Assistant Team Leader, Randal Scott and Christopher Grundler, are DOE (Headquarters) employees. The Oak Ridge Operations Office representative on the Survey Team is Vincent Fayne, also a DOE employee. The remainder of the Survey Team consists of contractor personnel from the NUS Corporation. They are listed with their technical areas of expertise as follows:

William Smith - NUS Coordinator/Air Quality

Michael Malloy - Quality Assurance/TSCA

Richard Tarbert - Surface Water

Henry Firstenberg - Air Quality

David Dougherty - Radiation

Carl Yates - Radiation

Peter Alexandro - RCRA

Gerald Kelly - CERCLA

Doughlas Riddle - Hydrogeology

Joseph Crist - Air Quality

c. What is the activity schedule and completion date of the Survey?

Answer: The pre-survey site visit was conducted May 5 and 6, 1986. The Survey was conducted from June 16 through 27, 1986. Sampling and analysis to be done in accordance with the sampling plan developed during the survey will begin in early August and will be conducted for approximately four weeks. Within a month after the availability of the analytical results, an Interim Report will be completed.

d. Please indicate what aspects of this Survey are being performed in-house or under contract.

Answer: As noted in response to question 5.b., the Survey is managed by DOE personnel with contractor support to provide additional multi-disciplinary technical experts on the teams.

Question 6: When do you plan to issue the revised DOE Safety and Quality Assurance Orders?

Answer: July 1986

Question 7: What is the status of your analysis of policy options for the DOE concerning the effects of National environmental policy and regulations on U.S. energy industries and energy supply and demand?

ANSWER: This effort is not a single analysis but is an ongoing process conducted by my Office of Environmental Analysis (OEA). During the period July 1, 1985 to July 1, 1986 the following examples of this type of analyses were carried out:

Proposed Legislation

- Analysis has been conducted on EPA, House, Senate and final versions of bills to amend the Safe Drinking Water Act (H.R.1650, S.124) and the Clean Water Act (H.R.8 S.1128). We have also tracked developing legislation on ground water protection.

- Analyses have been conducted to assess the effect of CERCLA reauthorization proposals on U.S. energy industries. This includes both regulatory and financing provisions. DOE is also developing a data base on energy industry waste stream characterization and disposal and treatment methods and costs for use in policy analysis.

- Continuing analysis of the costs and economic impacts of the many acid rain legislative proposals -- the latest being H.R.4567.

Proposed Regulations

- OEA prepared detailed technical analysis to the proposed rules on land disposal bans and the land disposal ban petition process. OEA identified serious drawbacks in the procedures for environmental dispersion modeling and risk assessment. EPA has subsequently withdrawn the petition process proposed rule and is reexamining the Land Ban Disposal procedures.

- o OEA prepared analysis on the proposed Small Quantity Generator Regulations. The comments reflect analysis that indicated economic impacts of the regulations to small business could be significant, and suggested two policy alternatives that would incorporate alternative inventory monitoring techniques and site specific considerations in the rule.

- o Based on analysis, OEA provided an energy industry perspective in discussions with EPA regarding the Interim Status of Land Disposal Facilities. Of particular concern was the expansion of the concept of physical existence of monitoring wells.

- o OEA has also completed analysis on proposed policy for stack height emissions balancing. Suggestions were made to broaden opportunities for cost-effective use of an emissions balancing alternative.

- o The proposed revision to the National Ambient Air Quality Standards (NAAQS) for Particulate Matter was also analyzed. Extensive comments were provided on proposed revisions to both primary (health) and secondary (welfare) standards. The major concerns were improper size indicator for health standard (i.e., too big), and welfare standards based on larger particles are unnecessary and imcomplete.

- o OEA analysis provided the substantive basis for the DOE position that EPA remove the limitations on the use of the DuPont waiver blend thus supporting the increased use of alcohol fuels.

- o Other analyses included:
  (a) Lising cadmium as a hazardous pollutant.
  (b) Rules for handling used oil.
  (c) Revisions to offshore oil and gas effluent guidelines.

Regulatory-Related

- o OEA participates in the National Acid Precipitation Assessment Program and conducts policy analyses of acid rain issues and proposals.

- Analysis continues in the area of Indoor Air Quality. This work helps provide the substantive basis for the DOE position that with the exception of guidelines relating to health effects, a non-regulatory solution is appropriate in this area.

- Analysis of the draft Regulatory Impact Assessment (RIA) for 1984 proposed listing of surface coal mines determined that EPA benefits estimates and assumptions provide a higher value for regulation than the likely actual value.

- Based on analysis, OEA has provided DOE with formal and informal comments on both type A and type B Natural Resource Damage Assessment methodologies impacts on energy industries. The technical comments focused on the assumptions and models used to determine both the existence of a damage and value of a resource.

- OEA analysis of the RIA on changes to the NAAQS for SO_2 identified many uncertainties, including:
  (a) representations of air pollution conditions
  (b) adequacy of experimental designs
  (c) other explanatory factors ignored
  (d) practical consequences of health outcomes

- National Energy Policy Plan is mandated by the DOE Organization Act, P.L.95-91. The Act requires, in Title VIII-Energy Planning that an assessment and evaluation be conducted on the effects of long-term trends of energy utilization on the social, environmental and economic requirements of the nation. OEA analysis provided these environmental assessments as a supplement to the National Energy Policy Plan.

- OEA analysis provided EPA technical comments regarding specification for gasoline volatility and recommended these regulations be formulated on the basis of ambient ozone levels. The EPA was considering utilizing the annual reduction in hydrocarbon emission as the regulatory basis.

Questions From Senator Domenici

Question 8: Please provide copies of the 19 statutory requirements briefly summarized in your FY 1987 budget submission.

Answer: Copies of the nineteen statutes that have applicability to DOE are attached.

(1) DOE Organization Act of 1977

(2) PL 79-585, Atomic Energy Act of 1946

(3) PL 83-703, Atomic Energy Act of 1954

(4) PL 91-956, Occupational Safety and Health Act (OSHA) of 1970

(5) PL 96-510, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

(6) PL 94-580, Resource Conservation and Recovery Act (RCRA)

(7) PL 91-190, National Environmental Policy Act (NEPA)

(8) PL 92-500, Clean Water Act

(9) PL 91-604, Clean Air Act

(10) PL 93-523, Safe Drinking Water Act

(11) PL 89-665, National Historic Preservation Act

(12) PL 93-205, Endangered Species Act

(13) PL 85-624, Fish and Wildlife Coordination Act

(14) PL 94-469, Toxic Substances Control Act

(15) PL 92-583, Coastal Zone Management Act

(16) PL 93-633, Hazardous Material Transportation Act

(17) Executive Order 11988, Floodplain Management

(18) Executive Order 11990, Protection of Wetlands

(19) PL 96-294, The Acid Precipitation Act of 1980

Question 9a: Would you provide for the record a description and copies of Secretary Herrington's September 18, 1985 initiatives to strengthen the environment, safety and health function within the Department?

Answer: On September 18, 1985, Secretary Herrington announced a series of initiatives to strengthen the environment, safety and health function within the Department of Energy. A press release announcing the initiatives is attached. These new initiatives are the result of a thorough review of the Department's environment, safety and health function by ES&H and senior management of the Department.

First, oversight responsibility for the environment, safety and health junction in the Department has been consolidated and upgraded under the new Assistant Secretary for Environment, Safety and Health. ES&H is now integrally involved in the operation of the Department at all levels, is directly overseeing the environmental and safety aspects of the Department's ongoing operations and necessary corrective actions, and is more integrally involved in decisions affecting those operations.

Second, ES&H will conduct a baseline Environmental Survey of all DOE facilities to identify Department-wide existing environmental problems and areas of potential risk and to prioritize corrective action. The onsite Survey activities, began in June and will take about 2 1/2 years to complete. The Survey will enable the Department to develop long range planning for correction environmental problems and reducing potential risks.

Third, ES&H will conduct Technical Safety Appraisals of DOE's nuclear facilities to determine compliance with safety requirements, industry lessons learned, and licensed facility requirements. The Technical Safety Appraisals will review all aspects of safety, including organization and administration, operations, maintenance, training and certification auxiliary systems, emergency readiness, technical support, security/safety interface, experimental activities, facility safety review, nuclear criticality safety, radiological protection, personnel protection, and fire protection. The Technical Safety Appraisals, begun in February 1986, will also be completed in about 2 1/2 years.

In addition, other elements of the new initiatives or our increased role include: (1) revising the environment, safety, and health orders in the Department to strengthen ES&H's oversight role and responsibilities with respect to DOE operations; (2) increasing guidance activities and enhancing liaison with State and Federal agencies; (3) taking a more aggressive ES&H role in the development and implementation of environmental and safety policy for the Department; (4) developing an improved field reporting and computer assisted tracking system; and (5) enhancing the professional development of ES&H staff.

Attachment Question 9A

U.S. DEPARTMENT OF ENERGY
OFFICE OF THE PRESS SECRETARY
WASHINGTON, DC 20585

DOENEWS:

NEWS MEDIA CONTACT:
David S. Devane, 202/252-8325

FOR IMMEDIATE RELEASE
September 18, 1985

HERRINGTON OUTLINES 3-POINT PLAN TO STRENGTHEN ENVIRONMENT, SAFETY AND HEALTH PROGRAMS

Secretary of Energy John S. Herrington today announced a restructuring of the Department's environmental, safety and health program that will feature centralized and upgraded control, a comprehensive environmental survey and special safety appraisals of DOE nuclear facilities.

"Today, I have ordered a series of actions to strengthen the environment, safety and health program within the Department of Energy," Herrington said. "This is a multi-faceted plan, of which there are three principal elements.

"First, oversight responsibility for the environment, safety and health function in the department will be consolidated and upgraded under the direction of an Assistant Secretary for Environment, Safety and Health. At present, oversight responsibility for environment and safety is scattered among the program Assistant Secretaries.

"Consolidating this function under a strong Assistant Secretary will establish line responsibility and top-management commitment to safety and environment. ES&H will be stronger and better organized," Herrington added. "It will have more oversight tools and it will be integrally involved in the operations of the department at all levels."

(MORE)

The second part of the plan involves a thorough environmental survey of all DOE facilities to identify problem areas and rank them in order of priority. Five teams will begin their review and preliminary sampling and analysis next year. Data from the survey will be used to develop a methodical approach to assigning priorities to ES&H concerns and working for their resolution.

The third facet of the ES&H upgrading is technical safety appraisals of DOE nuclear facilities. Herrington said that these appraisals will look at compliance with safety requirements in the department's nuclear facilities. The appraisals will take into account the safety lessons learned in private industry as well as licensed facility requirements.

"While the record of the department in this area has generally been a good one," Herrington stated, "I want to be certain that this department looks ahead to the many challenges of the future with a strong and aggressive program in place to meet our commitments to a clean environment, public health and safety.

"Some of our facilities have been in use for nearly 40 years and we have learned a great deal about handling hazardous activities.

"The environmental problems we are finding now at DOE facilities are, for the most part, legacies from the past, from activities conducted in a different atmosphere and under different standards than today's. What was acceptable in 1945 is not acceptable in 1985.

"For these reasons, shortly after becoming Secretary of Energy I ordered a thorough review of this department's environment and safety functions," Herrington explained. "I do not intend to let today's activities create problems for tomorrow. We must apply the sophisticated knowledge and techniques that we have acquired to our daily operations.

"This is my personal commitment to a quality environment and to the safety of our workers and all Americans. It is my pledge that the Department of Energy will be dedicated to correcting environmental problems we have now and establishing a framework for addressing environmental problems in the future."

DOE has about 16,500 employees, most of whom are at facilities outside Washington, including Chicago, San Francisco, Albuquerque, N.M., Oak Ridge, Tenn., Aiken, S. C., Las Vegas, Nev. and Richland, Wash., plus about 100,000 employees of contractors at such places as Los Alamos National Laboratory in New Mexico, Lawrence Livermore National Laboratory in California, Argonne National Laboratory in Illinois, Brookhaven National Laboratory in New York, Lawrence Berkeley National Laboratory in California, Sandia National Laboratory in New Mexico and the Idaho National Engineering Laboratory.

-DOE-

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Attachment Question 9A

U.S. DEPARTMENT OF ENERGY
OFFICE OF THE PRESS SECRETARY
WASHINGTON, DC 20585

DOE FACTS:

September 18, 1985

New DOE Initiatives in Environment, Safety and Health

FACT SHEET

Secretary of Energy John S. Herrington today announced a series of initiatives to strengthen the environment, safety and health function within the Department of Energy. There are three key elements of the long-range plan which will provide the framework for a strong emphasis on environmental and safety matters at the Department of Energy.

- Reorganization of ES&H
  - A new position of Assistant Secretary for Environment, Safety and Health has been established.
  - This ES&H function will include the consolidation of the Department's ES&H current functions, and the upgrading of ES&H responsibilities, and the oversight of new initiatives.
  - ES&H will be integrally involved in the operations of the Department at all levels.
  - ES&H will provide line management with more detailed information about the nature of the safety and environmental problems to be dealt with, and will oversee more directly the corrective action to be taken and the safety and environmental aspects of ongoing operations.
- The Environmental Survey
  - ES&H will conduct a baseline survey of all DOE facilities to identify and prioritize areas of existing environmental risk.
  - The survey will be a management tool to enable long-range planning, to correct any problems, to ensure compliance and to reduce identified areas of risk.
  - Details of the survey will include:
    - All DOE facilities, and all programs.
    - All media (air, water, soil).
    - All areas of environmental regulation.
    - Sufficient preliminary sampling and analysis to determine the nature of the problems.
    - Audits performed by ES&H using 5 teams led by DOE staff and supported by contractor experts.
  - It is estimated it will take approximately two years to complete the entire survey.

. Technical Safety Appraisals

. ES&H will perform multidisciplinary "on the ground" appraisals of DOE's major nuclear facilities to determine compliance with safety requirements, industry lessons learned, and licensed facility requirements, as appropriate.

. The program will include appraisals of all nuclear facilities.

. The program will include the following disciplines:

. Nuclear reactor safety
. Nuclear process facility safety
. Health physics
. Training
. Emergency preparedness
. Occupational medicine
. Occupational safety
. Fire protection safety
. Transportation/packaging safety

.Will take approximately three years to complete, although appraisals for each facility will be available to the field management as prepared.

Other principal elements of the Department of Energy's revitalized Environment, Safety and Health program, include the following:

. Field Reporting and Computer Assisted Tracking

. A computer-assisted information tracking system will be established to monitor compliance and progress in completion of corrective actions, and to assist ES&H in reducing areas of environmental and safety risk.

. The system will contain the baseline environmental and safety information, will appraise and audit information, and add new information supplied by the field on an ongoing basis.

. More aggressive internal environmental and safety policy for the department

. ES&H will issue new, revised orders and guidance.

. Enhanced efforts in the review of safety analysis reports

. Greater RCRA/CERCLA policy guidance for the field; liaison with state and federal agencies

Attachment Question 9A

Department of Energy
Washington, DC 20585

STATEMENT OF SECRETARY OF ENERGY JOHN S. HERRINGTON

ENVIRONMENT, SAFETY AND HEALTH
September 18, 1985

A CLEAN AND SAFE ENVIRONMENT IS A CONCERN THAT IS SHARED AND CHERISHED BY EVERY AMERICAN. IT IS AN ISSUE OF SPECIAL CONCERN AND IMPORTANCE TO ME BECAUSE THE DEPARTMENT OF ENERGY HAS MANY RESPONSIBILITIES AND OBLIGATIONS IN THE AREAS OF THE ENVIRONMENT, PUBLIC SAFETY AND HEALTH.

IT IS ESSENTIAL THAT THESE RESPONSIBILITIES ARE MET AND THAT THE OPERATIONS OF THE DEPARTMENT ARE CARRIED OUT IN A SAFE AND ENVIRONMENTALLY SOUND MANNER. AND IT IS IMPERATIVE THAT THESE OPERATIONS HAVE THE PUBLIC'S TRUST AND CONFIDENCE.

WHILE THE RECORD OF THE DEPARTMENT IN THIS AREA HAS GENERALLY BEEN A GOOD ONE, I WANT TO BE CERTAIN THAT THIS DEPARTMENT LOOKS AHEAD TO THE MANY CHALLENGES OF THE FUTURE WITH A STRONG AND AGGRESSIVE PROGRAM IN PLACE TO MEET OUR COMMITMENTS TO A CLEAN ENVIRONMENT, PUBLIC HEALTH AND SAFETY.

SOME OF OUR FACILITIES HAVE BEEN IN USE FOR NEARLY 40 YEARS. THE ENVIRONMENTAL PROBLEMS WE ARE FINDING NOW AT DOE FACILITIES ARE FOR THE MOST PART LEGACIES FROM THE PAST, FROM ACTIVITIES CONDUCTED IN A DIFFERENT ATMOSPHERE AND UNDER DIFFERENT STANDARDS THAN TODAY'S. WHAT WAS ACCEPTABLE IN 1945 IS NOT ACCEPTABLE IN 1985.

WE HAVE LEARNED A GREAT DEAL ABOUT HANDLING HAZARDOUS ACTIVITIES IN THE LAST FORTY YEARS.

I DO NOT INTEND TO LET TODAY'S ACTIVITIES CREATE PROBLEMS FOR TOMORROW. WE MUST APPLY THE SOPHISTICATED KNOWLEDGE AND TECHNIQUES THAT WE HAVE ACQUIRED TO OUR DAILY OPERATIONS.

FOR THESE REASONS, SHORTLY AFTER BECOMING SECRETARY OF ENERGY, I ORDERED A THOROUGH REVIEW OF THIS DEPARTMENT'S ENVIRONMENT AND SAFETY FUNCTIONS. THE REVIEW IDENTIFIED AREAS IN MANAGEMENT, PROGRAMS AND EMPHASIS WHICH COULD BE STRENGTHENED. IN RESPONSE, I HAVE DEVELOPED A PLAN WHICH WILL ENABLE THE DEPARTMENT TO ADDRESS ENVIRONMENTAL AND SAFETY ISSUES IN THE IMMEDIATE FUTURE AND IN THE LONG TERM.

TODAY, I HAVE ORDERED A SERIES OF ACTIONS TO STRENGTHEN THE ENVIRONMENT, SAFETY AND HEALTH PROGRAM WITHIN THE DEPARTMENT OF ENERGY. THIS IS A MULTI-FACETED PLAN, OF WHICH THERE ARE THREE PRINCIPAL ELEMENTS.

FIRST, OVERSIGHT RESPONSIBILITY FOR THE ENVIRONMENT, SAFETY AND HEALTH FUNCTION IN THE DEPARTMENT WILL BE CONSOLIDATED AND UPGRADED UNDER THE DIRECTION OF AN ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY AND HEALTH.

AT PRESENT OVERSIGHT RESPONSIBLITY FOR ENVIRONMENT AND SAFETY IS SCATTERED AMONG THE PROGRAM ASSISTANT SECRETARIES. CONSOLIDATING THIS FUNCTION UNDER A STRONG ASSISTANT SECRETARY WILL ESTABLISH LINE RESPONSIBILITY AND TOP-MANAGEMENT COMMITMENT TO SAFETY AND THE ENVIRONMENT.

ES&H WILL BE STRONGER AND BETTER ORGANIZED. IT WILL HAVE MORE OVERSIGHT TOOLS, AND IT WILL BE INTEGRALLY INVOLVED IN THE OPERATIONS OF THE DEPARTMENT AT ALL LEVELS.

SECOND, I HAVE DIRECTED ES&H TO CONDUCT A BASELINE SURVEY OF THE DEPARTMENT'S POTENTIAL ENVIRONMENTAL PROBLEMS, INCLUDING AIR, WATER AND HAZARDOUS WASTE. THIS SURVEY WILL COVER ALL DOE FACILITIES AND PROGRAMS. IT WILL ENABLE THE DEPARTMENT TO ESTABLISH PRIORITIES AND DEVELOP LONG-RANGE PLANNING FOR CORRECTING ENVIRONMENTAL PROBLEMS AND REDUCING POTENTIAL RISKS.

THIRD, ES&H WILL CONDUCT SAFETY APPRAISALS AT DOE'S NUCLEAR FACILITIES. THESE WILL BE ON-SITE TECHNICAL APPRAISALS OF ALL ASPECTS OF SAFETY, INCLUDING NUCLEAR REACTOR SAFETY, OCCUPATIONAL SAFETY, FIRE PROTECTION, AND TRANSPORTATION AND PACKAGING SAFETY.

THIS IS MY PERSONAL COMMITMENT TO A QUALITY ENVIRONMENT AND THE SAFETY OF OUR WORKERS AND ALL AMERICANS.

IT IS MY PLEDGE THAT THE DEPARTMENT OF ENERGY WILL BE DEDICATED TO CORRECTING ENVIRONMENTAL PROBLEMS WE NOW HAVE AND ESTABLISHING A FRAMEWORK FOR ADDRESSING ENVIRONMENTAL PROBLEMS IN THE FUTURE.

Question 9b: Would you describe the steps that have been taken to implement each initiative?

Answer: Since Secretary Herrington announced his Environment, Safety and Health initiatives in September of 1985, much has been accomplished toward achieving the initiatives. The reorganization of the headquarters ES&H function is essentially complete, and the new ES&H office is becoming integrally involved in the operations of the Department at all levels under the leadership of the new Assistant Secretary.

Field work has been completed for the first four Technical Safety Appraisals, and planning is well underway for four additional Technical Safety Appraisals this fiscal year. Included in the second group is N-Reactor in Hanford, Washington and four reactors at the Savannah River site in Aiken, South Carolina. At the Secretary's direction, we have accelerated the schedules for the review of these two sites as part of our commitment to conduct a special review in light of the accident at the Chernobyl power plant. In addition, the Secretary has requested that several special reviews be made of N-Reactor because it is the only one of the five that utilizes a graphite moderating system.

Planning and preparatory activities for the Environmental Survey have been completed. During the month of June, 1986 the baseline at the Feed Materials Production Center in Fernald, Ohio was conducted. The Fernald survey is being conducted by a team of experts under the direction of a DOE team leader and assistant team leader. It covers all areas of environmental concern including air pollution, water pollution, soil contamination and hazardous waste management. The

survey team will observe operations, review records and documents, interview plant personnel and study environmental conditions at the site. Current plans call for 4 other sites to be initiated by the Environmental Survey in FY 1986. These 4 sites are the Mound Plant in Ohio, the Portsmouth Gaseous Diffusion Plant in Ohio, the Rocky Flats Plant in Colorado, and the Hanford Reservation in the State of Washington.

Question 10: Explain briefly the Secretary of Energy's safety policies and standards.

Answer: It is the policy of the Department of Energy (DOE) to conduct its operations in a manner that protects the health and safety of its employees, contractors, and the public. It is intended that all activities of the Department and its contractors consistently reflect the Department's paramount concern for and commitment to this goal and that they comply with the spirit as well as the letter of applicable health and safety statutes, regulations, orders and standards. In addition, DOE is committed to good health and safety practices in all of its activities to reduce any potential safety or health risks and to reduce exposures to hazardous substances and ionizing radiations to as low as reasonably achievable.

Line managers at all levels at DOE Headquarters and in the field are held responsible for conducting activities of the Department under their purview in a matter that assures the health and safety of the workers and the public. As set forth in applicable DOE Orders, the Assistant Secretary for Environment, Safety and Health establishes policy for the protection of health and safety in DOE's programs, establishes applicable health and safety criteria, oversees its implementation, and assures its effectiveness through an institutional review process which includes appraisals, reviews of critical documents, concurrence in the initial construction and startup of major new facilities, and the resolution of issues important to safety. The Assistant Secretary for Environment, Safety and Health also provides support to Headquarters program and field organizations to insure implementation of this policy.

DOE contractors have a primary responsibility to meet DOE safety and health requirements in all of the activities they undertake on behalf of the Department. DOE vigorously oversees the contractors' activities to assure compliance with this policy.

Question 11: What is DOE's policy regarding compliance by DOE facilities with State environmental regulations?

Answer: Consistent with Executive Order 12088, it is DOE's policy to comply with all applicable environmental standards, including applicable State regulations. DOE's Environmental Policy Statement, issued in January 1986, clearly states that it is DOE's policy to conduct the Department's operations in compliance with the letter and spirit of applicable environmental statutes, regulations and standards.

POST-HEARING QUESTION AND ANSWER

FROM SENATOR PETE V. DOMENICI

FOR DR. TRIVELPIECE

Relating to

FY 1987 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

June 23, 1986

Question: Please supply the following MFE budget information for each of the laboratories listed below. The BA and BO figures should be supplied for total operating expenses, total capital equipment, total construction, and total MFE budgets by laboratory. For the same laboratories, list in addition the BA and BO figures for GPP and GPE, and line-item and major-device-fabrication projects, showing the operating, capital, and construction totals for each project. This budget information is requested for FY 1977 through FY 1985, plus the budgets allocated to date in FY 1986, and projected additional allocations in FY 1986, and the projected FY 1987 allocations based on the President's FY 1987 budget. This budget information is requested for the following laboratories: PPPL, LLNL (excluding the National MFE Computer Center), ORNL (excluding the Fusion Engineering Design Center), GA Technologies, LANL, and MIT.

To permit appropriate correlations, please submit the number of PhD staff supported by the MFE budgets at the above-listed laboratories (note the exclusion of the Computer Center and FEDC) for the same years, FY 1977 through FY 1987.

Answer: I would like to provide tables as inserts for the record that would include all of that information.

MAGNETIC FUSION ENERGY PROGRAM SUPPORT OF PHDS AT MAJOR CONTRACTOR SITES

	LANL	LLNL*	PPPL	MIT	ORNL**	GA
FY 1977.....	87	64	72	15	141	60
FY 1978.....	82	64	101	16	122	65
FY 1979.....	76	73	107	18	119	68
FY 1980.....	76	74	110	23	127	70
FY 1981.....	75	73	106	28	133	73
FY 1982.....	68	72	114	33	134	73
FY 1983.....	68	66	118	45	136	78
FY 1984.....	67	69	119	44	127	78
FY 1985.....	68	65	117	46	103	72
FY 1986 (Est.)	60	59	115	49	101	59
FY 1987 (Est.)	52	52	111	45	101	55

* Excludes PHDs for the National MFE Computer Center.
**Excludes PHDs for the Fusion Engineering Design Center.

Magnetic Fusion Energy

(Dollars in Thousands)

	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981		FY 1982	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Princeton Plasma Physics Lab												
Operating Expenses.	40,262	37,380	37,515	40,248	47,882	49,119	51,348	52,142	66,787	75,381	78,383	76,480
Capital Equipment..	5,315	1,999	4,980	6,412	4,230	5,498	6,930	4,774	8,186	7,473	9,345	11,313
Construction.....	76,442	18,309	72,350	38,039	46,456	61,213	37,100	82,962	31,100	50,644	41,500	47,015
Total.....	122,019	57,688	114,845	84,699	98,568	115,830	95,378	139,878	106,073	133,498	129,228	134,808
*GPP.....	1,442	568	1,350	2,012	1,400	761	1,000	1,295	1,100	987	1,400	1,521
*Line Items:												
Tokamak Fusion Test Reactor.....	75,000	17,741	71,000	36,027	42,000	57,647	35,000	80,593	30,000	49,450	40,100	45,494
PDX Neutral Beams..	0	0	0	0	3,056	2,805	1,100	1,074	0	207	0	0
*MDF:												
PDX MOD.....	0	0	0	0	0	0	0	0	170	170	0	0
Poloridal Divertor Exp (PDX).....	8,901	8,232	3,654	4,528	790	790	0	0	0	0	0	0
PLT Neutral Beams..	1,675	1,585	0	0	0	0	0	0	0	0	0	0
PDX Neutral Beams..	621	570	983	894	0	0	0	0	0	0	0	0
PLT Coil Tests.....	847	780	0	0	0	0	0	0	0	0	0	0
PLT RF System.....	0	0	1,221	1,022	1,100	1,100	500	557	0	0	0	0
Spheromak.....	0	0	0	0	0	0	1,000	1,000	2,342	2,411	1,960	2,345
RF MOD.....	0	0	0	0	0	0	0	0	0	0	300	192
PDX-ECH.....	0	0	0	0	0	0	0	0	660	501	1,110	1,126

*Dollars included in the "Total" line.

	FY 1983		FY 1984		FY 1985		FY 1986		FY 1987	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Princeton Plasma Physics Lab										
Operating Expenses.	117,990	113,396	120,430	120,015	108,355	108,212	85,610	85,693	87,860	87,860
Capital Equipment..	10,265	8,117	8,896	9,427	5,920	9,187	6,000	6,000	4,500	4,500
Construction.....	1,000	15,517	1,000	5,476	1,100	1,865	874	1,558	500	1,139
Total.....	129,255	137,030	130,326	134,918	115,375	119,264	92,484	93,251	92,860	93,499
*GPP.....	1,000	812	1,000	666	1,100	1,241	874	1,558	500	1,139
*Line Items:										
Tokamak Fusion Test Reactor.....	0	14,705	0	4,810	0	624	0	0	0	0
*MDF:										
Beta Exp. (PBX-Upgrade.....	0	0	0	0	0	0	5,150	5,150	3,833	3,833
Spheromak.....	2,324	2,138	0	0	0	0	0	0	0	0
RF MOD.....	2,600	2,739	1,700	1,830	0	0	0	0	0	0

*Dollars included in the "Total" line.

	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981		FY 1982	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Lawrence Livermore National Lab**												
Operating Expenses.	31,094	27,767	37,737	34,525	42,850	43,692	47,095	49,090	39,081	43,824	47,449	48,841
Less NMFECC.....	- 4,274	- 4,019	- 6,186	- 6,034	- 8,360	- 8,295	- 9,210	- 8,985	- 9,651	- 9,720	- 11,370	- 11,140
Subtotal.....	26,820	23,748	31,551	28,491	34,490	35,397	37,885	40,105	29,430	34,104	36,079	37,701
Capital Equipment..	3,292	3,513	4,619	6,104	4,899	3,807	4,880	3,526	6,694	7,403	6,122	5,874
Less NMFECC.....	- 732	- 181	- 880	- 1,846	0	- 1,164	- 199	- 111	- 1,779	- 1,967	- 2,094	- 1,956
Subtotal.....	2,560	3,332	3,739	4,258	4,899	2,643	4,681	3,415	4,915	5,436	4,028	3,918
Construction.....	7,509	3,165	14,000	9,042	40,000	27,485	28,200	37,119	25,000	28,144	39,858	33,268
Total.....	36,889	30,245	49,290	41,791	79,389	65,525	70,766	80,639	59,345	67,684	79,965	74,887
*MDF:												
TMX.....	3,134	2,922	8,503	6,902	0	0	400	400	10,000	9,521	913	1,353
*GPP.....	0	0	0	0	0	0	0	0	0	0	0	27
*Line Item:												
Computer Center....	5,000	134	0	848	0	3,062	0	939	0	17	0	0
High Intensity Neutron Facility..	2,509	3,031	0	1,627	0	17	0	114	0	19	0	0
Mirror Fusion Test Facility - B.....	0	0	14,000	6,567	40,000	24,406	28,200	36,066	25,000	28,108	39,858	33,241

* Dollars included in the "Total" line.
**Excludes funding for the National MFE Computer Network.

	FY 1983		FY 1984		FY 1985		FY 1986		FY 1987	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Lawrence Livermore National Lab**										
Operating Expenses.	57,674	57,571	70,907	70,520	69,349	66,748	63,654	65,927	54,890	54,890
Less NMFECC.....	- 12,753	- 12,653	- 13,646	- 13,379	- 15,561	- 13,377	- 14,982	- 16,732	- 16,340	- 16,340
Subtotal.....	44,921	44,918	57,261	57,141	53,788	53,371	48,672	49,195	38,550	38,550
Capital Equipment..	5,075	4,703	5,210	5,170	3,445	6,191	3,520	3,520	315	315
Less NMFECC.....	- 600	- 853	- 900	- 166	- 35	- 35	- 93	- 93	- 215	- 215
Subtotal.....	4,475	3,850	4,310	5,004	3,410	6,156	3,427	3,427	100	100
Construction.....	41,080	40,987	31,000	40,695	21,100	29,427	4,178	5,011	200	630
Total.....	90,476	89,755	92,571	102,840	78,298	88,954	56,277	57,633	38,850	39,280
*MDF: D-III Extended Pulse NB.....	0	0	0	0	0	0	1,700	1,700	0	0
*GPP.....	1,080	481	1,000	946	1,000	1,175	289	859	200	630
*Line Item: Mirror Fusion Test Facility - B.....	40,000	40,506	30,000	39,749	20,100	28,252	3,889	4,152	0	0

* Dollars included in the "Total" line.
**Excludes funding for the National MFE Computer Network.

	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981		FY 1982	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Los Alamos National Laboratory												
Operating Expenses.	17,802	16,384	14,661	15,542	16,520	16,410	12,745	16,725	17,627	18,790	18,065	18,032
Capital Equipment..	2,014	1,537	2,900	2,214	2,247	2,098	2,473	3,361	2,457	2,200	1,320	2,196
Construction.....	1,345	603	0	1,646	0	294	0	0	0	0	0	0
Total.....	21,161	18,524	17,561	19,402	18,767	18,802	15,218	20,086	20,084	20,990	19,385	20,228
*Line Item: Intense Neutron Source Facility...	1,345	603	0	1,646	0	294	0	0	0	0	0	0
*MDF:												
ZT-40.....	2,275	2,220	4,130	4,543	0	0	0	0	0	0	0	0
LLX.....	148	140	0	0	0	0	0	0	0	0	0	0
ZT-40 Upgrade.....	0	0	0	0	0	0	0	0	0	0	180	161

*Dollars included in the "Total" line.

	FY 1983		FY 1984		FY 1985		FY 1986		FY 1987	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Los Alamos National Laboratory										
Operating Expenses.	18,527	18,227	19,673	19,478	19,230	18,926	16,619	16,419	15,940	15,740
Capital Equipment..	691	1,023	1,056	1,112	694	966	3,888	3,888	3,280	3,280
Construction.....	420	17	300	267	300	76	385	518	300	345
Total.....	19,638	19,267	21,029	20,857	20,224	19,968	20,892	20,825	19,520	19,365
*GPP.....	420	17	300	267	300	76	385	518	300	345
*MDF:										
ZT-40 Upgrade.....	200	179	600	627	0	0	0	0	0	0
Reversed Field Pinch.....	0	0	0	0	0	0	3,420	3,220	6,600	6,400

*Dollars included in the "Total" line.

	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981		FY 1982	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
GA Technologies												
Operating Expenses..	24,250	22,342	24,063	20,348	9,377	10,773	13,451	17,278	18,511	18,146	21,225	21,635
Capital Equipment...	2,185	1,430	3,023	3,134	2,185	2,642	2,940	3,259	2,960	3,032	2,405	2,632
Construction.....	0	0	0	0	11,397	10,651	2,500	4,500	0	1,018	0	338
Subtotal.....	26,435	23,772	27,086	23,482	22,959	24,066	18,891	25,037	21,471	22,196	23,630	24,605
*MDF:												
Doublet - III.....	13,555	12,539	4,624	4,517	0	0	0	0	0	0	0	0
D-III Neutral Beam.	0	0	3,005	2,718	0	0	0	0	0	0	0	0
D-III Vacuum Vessel	0	0	0	0	0	0	200	180	230	230	0	0
ECRH Experiment....	0	0	0	0	0	0	300	300	690	671	2,237	1,830
*Line Item:												
D-III Neutral Beams.....	0	0	0	0	11,397	10,651	2,500	4,500	0	1,018	0	338
Massachusetts Institute of Tech.												
Operating Expenses	4,948	4,586	9,238	7,940	8,170	9,249	11,887	12,215	12,282	13,248	17,899	17,401
Capital Equipment.	600	127	1,200	0	1,393	508	1,579	1,654	1,367	1,080	2,115	626
Total.....	5,548	4,713	10,438	7,940	9,563	9,757	13,466	13,869	13,649	14,328	20,014	18,027
*MDF:												
Alcator.....	1,749	1,614	3,594	3,400	700	700	0	0	0	0	0	0
Alcator RF.....	0	0	207	200	2,050	2,050	2,500	2,659	0	0	0	0
Alcator D.....	0	0	621	600	0	0	0	0	0	0	0	0
TARA.....	0	0	0	0	0	0	0	0	250	253	2,880	2,830

*Dollars included in "Total" line.

1200

	FY 1983		FY 1984		FY 1985		FY 1986		FY 1987	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
GA Technologies										
Operating Expenses..	28,932	28,417	35,676	35,081	35,783	36,403	34,618	35,341	27,380	27,380
Capital Equipment...	2,580	2,882	3,252	2,597	2,936	3,095	2,301	2,301	1,775	1,775
Construction.....	0	232	0	0	0	0	0	0	0	0
Subtotal.....	31,512	31,531	39,928	37,678	38,719	39,498	36,919	37,642	29,155	29,155
*MDF:										
D-III Vacuum Vessel	4,600	4,100	5,600	5,399	5,800	6,000	2,013	2,714	0	0
D-III Extended Pulse NB.....	0	0	0	0	0	0	1,171	1,171	3,000	3,000
ECRH Experiment....	2,350	2,350	2,000	2,000	0	0	0	0	0	0
*Line Item:										
D-III Neutral Beams.....	0	232	0	0	0	0	0	0	0	0
Massachusetts Institute of Tech.										
Operating Expenses	22,090	22,674	23,941	23,996	23,245	23,137	22,521	22,521	17,725	17,725
Capital Equipment.	2,596	3,080	2,442	2,415	2,451	3,260	2,034	2,034	80	80
Total.....	24,686	25,754	26,383	26,411	25,696	26,397	24,555	24,555	17,805	17,805
*MDF:										
TARA.....	6,000	6,000	3,091	3,091	0	0	0	0	0	0

*Dollars included in "Total" line.

	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981		FY 1982	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Oak Ridge National Laboratory**												
Operating Expenses	39,124	34,487	35,883	34,273	35,373	37,680	46,574	50,216	48,177	51,445	55,787	55,252
Capital Equipment.	4,111	2,635	7,481	7,092	7,330	5,548	6,892	7,414	9,328	6,424	12,720	10,240
Construction.....	0	0	2,290	2,319	11,834	7,206	7,600	8,799	19,700	13,759	23,746	16,206
Subtotal.....	43,235	37,122	45,654	43,684	54,537	50,434	61,066	66,429	77,205	71,628	92,253	81,698
Less: FEDC.....	0	0	0	0	- 780	- 781	- 3,300	- 3,774	- 3,170	- 3,228	- 3,801	- 3,756
Total.....	43,235	37,122	45,654	43,684	53,757	49,653	57,766	62,655	74,035	68,400	88,452	77,942
*GPE.....	0	0	1,950	975	1,600	481	3,000	2,024	3,000	2,644	3,260	2,588
*GPP.....	0	0	2,290	2,319	2,630	2,471	3,000	2,910	3,300	2,112	4,300	3,908
*Line Item:												
Large Coil Test Facility.....	0	0	0	0	6,654	2,253	2,000	4,940	6,500	6,205	6,000	6,061
PDX Neutral Beams.	0	0	0	0	2,550	2,482	600	949	0	25	0	9
EBT-P.....	0	0	0	0	0	0	2,000	0	5,400	4,895	13,446	5,104
ISX.....	0	0	0	0	0	0	0	0	4,500	522	0	1,124
*MDF:												
Ormak Upgrade.....	1,775	1,638	0	0	0	0	0	0	0	0	0	0
Impurity Study Exp (ISX).....	1,779	1,642	1,707	1,811	0	0	600	600	0	0	0	0
PLT Neutral Beams.	1,403	1,294	0	0	0	0	0	0	0	0	0	0
EBT.....	216	178	0	0	0	0	0	0	0	0	0	0
ISX Beams.....	0	0	2,121	1,693	1,000	1,056	1,000	913	0	0	0	0
PDX Neutral Beams.	0	0	1,035	1,205	0	0	0	0	0	0	0	0
ISX ECH.....	0	0	0	0	400	400	0	0	0	0	0	0
ISX Bundle Divertor.....	0	0	0	0	500	500	1,400	1,077	500	862	0	0

* Dollars included in the "Total" line.
**Excludes funding for the Fusion Engineering Design Center.

	FY 1983		FY 1984		FY 1985		FY 1986		FY 1987	
	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O	B/A	B/O
Oak Ridge National Laboratory**										
Operating Expenses	68,061	58,963	56,086	58,164	52,946	54,056	46,384	52,531	45,319	45,319
Capital Equipment.	12,140	13,061	11,984	8,920	7,943	10,890	8,575	8,575	6,270	6,270
Construction.....	3,500	13,464	4,200	5,701	7,000	3,795	7,216	7,571	7,200	9,373
Subtotal.....	83,701	85,488	72,270	72,785	67,889	68,741	62,175	68,677	58,789	60,962
Less: FEDC.....	- 3,975	- 4,135	- 5,110	- 5,082	- 4,810	- 4,972	- 4,429	- 4,429	- 4,100	- 4,100
Total.....	79,726	81,353	67,160	67,703	63,079	63,769	57,746	64,248	54,689	56,862
*GPE.....	4,000	2,571	4,000	3,504	3,800	3,443	3,801	3,801	3,820	3,820
*GPP.....	3,500	4,398	4,200	3,485	7,000	3,866	7,216	7,571	7,200	9,373
*Line Item:										
Large Coil Test Facility.....	0	1,662	0	1,135	0	0	0	0	0	0
EBT-P.....	0	6,550	0	1,099	0	- 71	0	0	0	0
ISX.....	0	854	0	- 18	0	0	0	0	0	0
*MDF:										
ATF.....	2,300	54	5,725	1,826	6,425	6,768	4,744	10,389	706	863

* Dollars included in the "Total" line.
**Excludes funding for the Fusion Engineering Design Center.

POST-HEARING QUESTIONS AND ANSWERS

FROM SENATOR BILL BRADLEY

FOR DR. TRIVELPIECE

Relating to

FY 1987 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

JUNE 23, 1986

SET I

Question 1: What radon related research does the DOE now support? What is the level of this support?

Answer: Three offices within the Department of Energy support radon related research. They are the Office of Energy Research/Office of Health and Environmental Research, Conservation and Renewable Energy/Office of Building and Community Systems, and the Bonneville Power Administration. The basic radon research conducted by the Department of Energy encompasses studies of radon sources, pathways and behavior, lung dosimetry and health effects, instrumentation, epidemiology and energy efficient mitigation strategies. The level of this support for 1986 follows:

DOE RADON RESEARCH
OFFICE OF ENERGY RESEARCH
(in thousands)

Research Category/ Laboratory/Project Title	FY 1986 Estimate
BIOLOGICAL AND ENVIRONMENTAL RESEARCH	
Sources and Pathways	
Lawrence Berkeley Laboratory	
Radon Characterization	96
Institute of Mining and Technology-New Mexico	
Source Characterization	49
Total Sources and Pathways	145
Health Effects	
University of New Mexico	
Lung Cancer Epidemiology	173
Argonne National Laboratory	
Oncogences and Human Radium Carcinogenesis	385
Pacific Northwest Laboratory	
Inhalation Hazards to Uranium Miners	500
Total Health Effects	1058

Instrumentation	
Environmental Measurements Laboratory	
Instrumentation Development	335
Total Instrumentation	335
Subtotal Radon Research - Biological and Environmental Research	$1537
CONSERVATION AND RENEWABLE ENERGY	
Lawrence Berkeley Laboratory	
Source Characterization	
Building Entry Mechanism, Mitigation	250
BONNEVILLE POWER ADMINISTRATION (BPA)	
In-house	
Residential Weatherization Program - Radon Monitoring	250
Radon Measurement Protocols	120
Lawrence Berkeley Laboratory	
Radon Sources; Mitigation Strategies	100
Subtotal (BPA)	470
Total DOE Radon Research	2,257

Question 2: To what degree is this DOE supported research directed at homeowners? Is DOE presently involved in any epidemiology studies on lung cancers in residential areas?

Answer: All radon research currently supported by the Department of Energy is either directly or indirectly providing the scientific data required to reduce the uncertainties surrounding the question of residential radon exposure and lung cancer. Studies of sources and pathways of radon entry, radon and radon progeny behavior, instrumentation development, validation and quality assurance all contribute significantly to the knowledge ultimately required to understand, define and reduce the exposure of homeowners to radon. In addition, animal studies of radon and smoking exposures, as well as lung microdosimetry provide health effects data to help reduce the uncertainties in the radon dose effect relationship in lung cancer induction. These studies cannot be performed directly in humans. Epidemiologic studies to provide data on human radon exposures and lung cancer induction are being performed as well. Fundamental studies within DOE to develop energy efficient mitigation strategies are also of obvious direct importance to homeowners.

Two epidemiologic studies, one of radon exposures in homes and one in U.S. uranium mines are examining the relationship of radon exposures to lung cancer. The BER study of female lung cancer cases in eastern Pennsylvania, initiated in 1986, is the major U.S. epidemiologic study of residential radon exposures.

DOE published a handbook on indoor air quality in January 1986, which provides a comprehensive overview of radon related research. One section of this handbook is specifically directed at homeowners.

Question 3: The information on the health effects of radon exposure we have now is based on the study of underground miners. Extrapolating the results of these studies to the general public--especially children--has been questioned. Does the DOE plan to support epidemiology research directed at individuals that spend a majority of their time indoors, in particular, children, women and homebound individuals?

Answer: While the information now available on the health effects of radon exposure from studies of underground miners cannot answer all the questions relating to radon exposures of the general public, it has provided the framework for defining the radon issue with respect to levels of exposure, other potentially confounding pollutants in inhaled air, and the relationship of smoking to radon lung cancer induction. The extrapolation required to relate this information to the general public, with the potential for significant impact on great numbers of homeowners, now necessitates further reduction in the remaining uncertainties. Inasmuch as children will not get lung cancer for many years, and housebound individuals may have other confounding disabilities, DOE has no plans to directly study as such, individuals who spend a great deal of their time indoors. However, the BER residential radon study in eastern Pennsylvania will be looking at female non-smoking lung cancer cases. Although many of these women will not have had jobs outside the home, this will not be known until the lung cancer cases are identified. Efforts are also underway to coordinate, where possible, the DOE epidemiologic study in Pennsylvania with several other epidemiologic studies in the U.S. and Canada.

Question 4: Are you considering any special studies of the Reading Prong and surrounding areas?

Answer: At the present time, BER is not planning any special studies of the Reading Prong and surrounding areas. However lung cancer cases in the BER epidemiologic study now underway in eastern Pennsylvania may reside in the Prong area. Additionally, coordination will be attempted with other epidemiologic studies planned in New York and New Jersey, also Reading Prong states.

A fundamental research project to be performed in high radon houses in the New Jersey portion of the Reading Prong will be conducted cooperatively by the DOE Office of Conservation and Renewable Energy and EPA. The objective of this research is the development of generic energy efficient mitigation strategies.

6/23/86 auth. Hearing IN/DK

QUESTIONS FOR THE OFFICE OF ENERGY
RESEARCH ON DOE SPONSORED RADON RESEARCH

Submitted by Senator Bill Bradley

1. What radon related research does the DOE now support? What is the level of this support?

2. To what degree is this DOE supported research directed at homeowners? Is DOE presently involved in any epidemiology studies on lung cancers in residential areas?

3. The information on the health effects of radon exposure we have now is based on the study of underground miners. Extrapolating the results of these studies to the general public--especially children--has been questioned. Does the DOE plan to support epidemiology research directed at individuals that spend a majority of their time indoors, in particular, children, women and homebound individuals?

4. Are you considering any special studies of the Reading Prong and surrounding areas?

POST-HEARING QUESTIONS AND ANSWERS

FROM SENATOR [redacted]

FOR DR. TRIVELPIECE

Relating to

FY 1987 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

JUNE 23, 1986

SET II

Question 1: The Idaho National Engineering Laboratory (INEL) has some unique research activities and facilities -- including the recently completed Idaho Lab Facility — which could be of great value to the State's university personnel. Could you summarize the kinds of university/lab arrangements at INEL that are being carried out under your "University Research Support" program?

Answer: All of the contractors which comprise the Idaho National Engineering Laboratory (INEL), including Westinghouse, EG&G, Mountain States Energy, and Argonne West Laboratory, have made excellent progress in the last several years in strengthening and expanding their university relationships and programs. A site-wide INEL University Committee has been organized to review and oversee all university-related activities at the site, and to develop and implement new faculty and student research and education programs. An INEL university consortium has been organized with 21 member institutions ranging from Alaska to North Dakota. Joint research projects have been developed between INEL contractors and these universities, and master contracts have been developed to simplify the process of supporting these joint research projects. Over the last two years several dozen INEL scientists and engineers have been involved in teaching one or more courses at local universities. Several thousand college and precollege students attend INEL-supported courses and seminars and tour the research facilities and laboratories on the site.

Leadership has been shown by the Idaho Operations Office and INEL staff in carrying out Secretary Herrington's direction to develop strong DOE-university relationships. INEL is developing into an excellent example of how DOE laboratories and contractor research facilities can work with local and regional universities to mutual benefit. In terms of the support provided by INEL university programs through the University Research Support Program, (URS) there are two major activities which the office of Energy Research supports. First, there is the administration of the university

nuclear reactor fuel fabrication program by EG&G through the URS University Reactor Fuel Assistance Program. The EG&G staff has provided consistently strong technical and administrative support to this essential activity. Second, through the URS University Laboratory Cooperative Program, the Department provides support for about 25 university faculty, student and postdoctoral research appointments each year at the various INEL facilities. These appointments are handled for INEL by the Associated Western Universities, one of the Laboratory Cooperative Program contractors. We plan to expand this support in coming years within the resources available to the overall Laboratory Cooperative effort.

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Question 2: The scientific capabilities at the Idaho Lab Facility are conducive to cooperative research efforts in connection with Sandia Livermore's Combustion Research Center. Is your Office looking into the possibility of such cooperative efforts?

Answer: We understand that the Idaho National Engineering Laboratory and the Sandia National Laboratory are currently working on a joint project involving a long term program for enhanced coal utilization. When the details of this proposal have been finalized the Department will perform an evaluation to determine its scientific merit and whether sufficient funds are available to permit funding.

Question: What is the FY 87 funding level for the Superconducting Super Collider (SSC)? What specific activities will be undertaken in FY 87? When will a decision be made to move forward with the project? When will the decision be made for site selection? Upon what criteria will site selection be based? Which States have indicated an interest in hosting the SSC project?

Answer: The Department has recently carried out an indepth review of the scientific, technical, and cost aspects of the SSC. This review forms a part of the input to the Department's decision this summer on whether to seek authorization to initiate construction of the project in FY 1988 or some future year. The direction and emphasis of the FY 1987 accelerator R&D program will depend on this decision.

During FY 1984-86, funding for SSC R&D has been a part of the high energy technology subprogram. The FY 1987 request for this subprogram and the SSC R&D would maintain overall an approximately constant level of effort with FY 1985 and FY 1986 pre-Gramm-Rudman-Hollings.

We believe we can accommodate the highest priority SSC needs within this request. Continued R&D on the magnets and other SSC systems will be needed in FY 1987. A major required activity will be systems tests of a set of full-scale prototype magnets connected in a string. There is a need to fabricate further magnet prototypes including important participation by industry to incorporate further cost saving ideas and manufacturing techniques. There is also a need for continued improvements to the superconducting wire and R&D studies on other SSC systems to develop cost and performance optimized designs.

It should be noted that the U.S. High Energy Physics program must have new research capabilities by the mid-1990's if it is to retain its capability to do forefront research. The Technology subprogram is

crucial to the long-range viability of the field because it provides the R&D necessary for these new capabilities. Any new frontier facility in this time frame will require the use of superconducting magnets. Thus, R&D and optimization of superconducting magnets has high priority, even independent of the decision on the SSC.

A decision will be made in the regular FY 1988 budget process on whether to include a request for FY 1988 construction authorization.

If the SSC were to be authorized for an FY 1988 construction start, I would anticipate that the site selection decision would be made in the summer of 1988. The selection would be based primarily on technical and cost considerations. These considerations have not yet been finalized, but the Department did request and receive (June 1985) a technical advisory from its contractor, the Central Design Group (CDG), on siting parameters. In this advisory the site criteria were grouped into eight broad categories: physical setting, environmental aspects, geology and tunneling, community resources, utilities, man-made disturbances, climate, and cost and schedule factors. A large number of sites throughout the country appear to satisfy these criteria. The Department plans that the selection process be open and fully competitive.

Most states have exhibited some interest in hosting the SSC project. Requests for information on the SSC have been received from all states. Since no decision has yet been made by the Department and the site selection process has not been initiated, the Department has not been following the activities or degree of interest of the various states.

Question 4: When is breakeven expected to be achieved at TFTR? Are there any other countries that have achieved or are soon expected to achieve breakeven at similar facilities?

Answer: Steady progress is being made in the TFTR experiment. The facility should be ready to achieve the plasma conditions required for equivalent breakeven in a deuterium plasma in FY 1987. With the completion of the TFTR tritium handling systems in FY 1989, TFTR should be capable of achieving actual breakeven in a D-T plasma in FY 1989. The JET experiment in Europe and the JT-60 experiment in Japan may also achieve equivalent breakeven plasma conditions in FY 1987, but by somewhat different approaches from TFTR.

JET will also be able to operate with tritium, but it is not expected to have its tritium systems operable until 1-2 years after TFTR. The JT-60 facility is limited to hydrogen operation and thus can only simulate the breakeven experiments.

Question 5: With what countries does the US already collaborate with respect to magnetic fusion research? Do you think this research would be jeopardized by a joint US-Soviet collaborator research effort? What other scientific ventures have we undertaken with the Soviet Union--especially large ventures comparative to the envisioned fusion effort, and as sensitive in terms of technology transfer?

Answer: The United States has formal agreements for collaborative fusion research with both Japan and the European Atomic Energy Community (Euratom). Some of these agreements include Canada and Switzerland as well. In addition, the United States has formal agreements for cooperative fusion work, that is, exchange of personnel and information, with the Soviet Union and the People's Republic of China.

There is a growing consensus among the world fusion program leaders on the appropriate next steps to be taken in fusion research, especially in terms of major facilities. Furthermore, the intention of the Geneva Summit fusion statement was to invite the other principal fusion programs into any US-Soviet initiated activity. Therefore, if a multilateral research activity were to be undertaken in the context of this growing consensus, it would build upon existing collaboration & would contribute to the world-wide technical program.

There have been no other comparable ventures undertaken by the Department of Energy with the Soviets involving activities of this magnitude or technology transfer sensitivity.

Question 6: In light of the Chernobyl accident, is anyone in the Department pursuing the alternative suggested by Defense Secretary Weinberger--that of international collaboration on fission power plant safety--as an alternative to fusion research, as an option for joint U.S./U.S.S.R. research?

Answer: The question of international collaboration on fission reactor safety will be addressed, as will other issues such as fusion, at the August 1986 meeting of the joint U.S./U.S.S.R. Committee on the Peaceful Uses of Atomic Energy.

Question 7: Will your office be involved in any post-Chernobyl epidemiological studies of the population in the vicinity of the Chernobyl?

Answer: The Chernobyl incident represents a unique opportunity to document the health and environmental consequences of a nuclear reactor accident. Such an assessment is directly related to the primary mission of the Department's Biological and Environmental Research Program "To develop the knowledge base necessary to identify, understand, and anticipate the long-term health and environmental effects of energy technologies and programs." Various options are under consideration for developing a cooperative program on information exchange with the USSR, either directly through the auspices of an international organization like the International Atomic Energy Agency by direct agreement involving a consortium of Federal agencies, or by DOE scientist-scientist interactions. None of these mechanisms has yet been fully realized.

Question 8: Within Basic Energy Science, the Department is reviewing various design and siting options for the proposed Advanced Steady-State Reactor (also known as the High Flux Reactor).

What criteria are being considered for the design of this reactor? What review process is established for choosing among the various design proposals?

Will the site selection process consider criteria such as remoteness, waste handling capabilities, and fuel handling capabilities, to assure that the most appropriate, most cost effective site is chosen?

Answer: The criteria being considered for the design of the proposed Advanced Steady-State Reactor include increased neutron flux over existing reactors and the need to accommodate research in neutron scattering, isotope production and radiation damage. Several studies have been completed which have established the need and rationale for such a facility, including the National Research Council report on Major Facilities for Materials and Related Disciplines and the Energy Research Advisory Board review of that report. Meetings and workshops have been held and will continue in order to allow scientific community input to the design process which will be under the lead of the Oak Ridge National Laboratory. Several years of research and development are anticipated before any specific design is chosen for construction. ORNL will manage the R&D effort where other laboratories will participate as appropriate. It is expected that an ORNL designed concept with scientific community and other laboratory input will be ready to be reviewed by a DOE review team no earlier than the summer of 1988, depending on the progress of the R&D effort.

The decision to site the reactor at ORNL was based on a management judgment concerning the best location for an advanced research reactor and considered ORNL's wide ranging experience in building and operating research reactors,

their base of ongoing research related to the activities to be undertaken at the new reactor such as neutron scattering, radiation effects, isotope production, and their base of knowledge achieved in conducting research and development on the reactor design. In addition the Department fully intends to satisfy all appropriate environmental, health and safety requirements prior to taking significant federal action on this project.

Question 9: Purely from the standpoint of an interested observer, what do you think of the concept of subseabed disposal of high-level nuclear waste? Do you think it is attractive enough that we ought to be pursuing the research as an alternative to geologic land disposal?

Answer: Legislation is in place which states that alternative methods must be explored for disposal of high-level nuclear waste. Research on the subseabed disposal alternative has been underway for several years. It is a small, high quality, scientific program which is developing information that will be necessary for a proper evaluation of the subseabed as a valid alternative to geologic land disposal. At present, the project is cost shared at about 50% by other countries. We may never use the subseabed alternative but we should know the environmental aspects of this scenario particularly if other nations may adopt subseabed as a viable disposal option.

POST-HEARING QUESTIONS AND ANSWERS

FROM SENATOR [redacted]

FOR DR. TRIVELPIECE

Relating to

FY 1987 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

JUNE 23, 1986

Accelerators

Question 1: DOE's budget proposal contemplates initiation of construction for the Continuous Electron Beam Accelerator (CEBAF) in Newport News, Virginia, and for several new facilities or major facility upgrades in the Basic Energy Sciences budget category.

Supply the Subcommittee with a schedule of spending for each of these facilities that shows construction and operating expenditures by year through the first two years of operation after construction is completed. What is the total commitment of funds being requested of Congress for each of these facilities?

Answer: The total estimated construction cost for the Continuous Electron Beam Accelerator Facility (CEBAF) is $236.0 million: FY 1987 = $25.0 million, FY 1988 = $65.0 million, FY 1989 = $65.0 million, FY 1990 = $55.0 million and FY 1991 = $26.0 million. The total estimated operating cost for CEBAF through FY 1993 is $100.8 million. This includes $26.3 million for R&D related to construction: Prior Years = $9.3 million, FY 1987 = $6.3 million, FY 1988 = $6.2 million and FY 1989 = $4.5 million. The total estimated operating cost for pre-operations and facility operations through FY 1993 is $74.5 million: FY 1989 - $2.0 million, FY 1990 = $6.5 million, FY 1991 = $12.0 million, FY 1992 = $27.0 million and FY 1993 = $27.0 million. The total commitment of funds being requested for CEBAF through the first two years of operation after completion of construction is $336.8 million.

The total estimated construction cost for the Los Alamos LANSCE/Experimental Hall is $17.5 million: FY 1987 = $5.0 million, FY 1988 = $8.5 million, and FY 1989 = $4.0 million. The facility operating costs are estimated to be $600,000 annually. Therefore, the total commitment being requested for FY 1987 through the first two years of operation for LANSCE is $18.7 million.

For the 1-2 GeV Synchrotron Radiation Source at LBL, the total estimated construction cost is $90.0 million to $100.0 million. The FY 1987 initial request of $1.5 million in construction funds and $1.5 million in R&D operating funds will be followed with a more definitive schedule and cost estimate based on a conceptual design. Some additional ongoing R&D is expected to be needed, amounting to about $5.0 million over the remaining construction period. It is projected that start up costs for this facility will be approximately $20.0 million. Based on experience with projects of a similar nature and technical complexity, the annual facility operating costs can be expected to be in the range of about 20 percent of the construction cost. Therefore, the total commitment being requested for FY 1987 through the first two years of operation for the 1-2 GeV Synchrotron Radiation Source is between $152.5 million and $166.5 million through FY 1993.

In addition to the projects mentioned above, the Department has requested in FY 1987 preconstruction R&D funding for three large facilities which are now very early in the planning phase. These facilities are the 6 GeV Synchrotron Radiation Laboratory at Argonne National Laboratory, the Advanced Steady State Reactor at Oak Ridge National Laboratory, and the Relativistic Heavy Ion Collider at Brookhaven National Laboratory. The budget for FY 1986 and the request for FY 1987 includes a total of $11.5 million in operating and equipment funds for these projects, $2.0 million in FY 1987 in the Nuclear Physics budget for the Relativistic Heavy Ion Collider, and $4.0 million in FY 1986 and $5.5 million in FY 1987 in the Basic Energy Sciences budget for the 6 GeV Synchrotron Radiation Laboratory and the Advanced Steady State Reactor. The Department intends that these

facilities be constructed in the future but more research is needed before a reliable total estimated cost, schedule, and detailed scope can be developed.

SSC

Question 2: We understand that research and development is proceeding on the Super Conducting Supercollider in the FY 1987 proposed budget. How much in the budget supports work on the SSC? What is the comparable figure for FY 1986? FY 1985?

Answer: During FY 1984-86, SSC R&D has been funded as part of the High Energy Technology subprogram, at the rate of $20 million per year. The FY 1987 request for this subprogram would maintain overall an approximately constant level of effort with FY 1985 and FY 1986 pre-Gramm-Rudman-Hollings. The direction and focus of accelerator R&D and the amount spent on SSC in FY 1987 will depend on the decisions taken by the Department this summer on whether to seek authorization to initiate construction of the project in FY 1988 or some future year. In any case, the U.S. High Energy Physics program must have new research capabilities by the mid-1990's if it is to retain its capability to do forefront research. Any new frontier facility in this time frame will require the use of superconducting magnets. Thus, R&D and optimization of superconducting magnets has high program priority.

SSC

Question 3: If current budget deficits force postponement of the decision to construct the SSC for at least five years, what would be the Department's recommendation for high-energy physics budgets in the interim? How much would continued research related to SSC cost? How would the Department readjust priorities within the program?

Answer: The SSC is the highest scientific priority for the future of the High Energy Physics Program. If the decision to construct the SSC were postponed for at least five years, the Department would adjust its strategy for high energy physics in order to optimize output from existing facilities, particularly the world forefront Tevatron and SLC colliders, and to extend the productive lifetime at the research frontier for these facilities by undertaking major facility upgrades. Generic advanced technology R&D on superconducting magnets and advanced accelerator concepts would initially be continued at about the present level, but would be intensified two-three years from now as the decision point approached and the program would begin to focus toward a specific facility proposal.

Magnetic Fusion Energy (MFE)

Question I: You have mentioned in your testimony that "due to a relaxation in the energy crisis situation, there is now less urgency to develop an energy supply system based on the nuclear fusion principle" and a revised MFE program was put into place last year.

a) Do you have any specific target date for the commercialization of MFE?

Answer: The current program plan calls for an economic and environmental assessment of fusion in the early 21st century. Assuming a favorable outcome, the establishment of the science and technology base for fusion would be completed and available for commercialization then.

b) Do we have enough trained scientists and engineers when we need MFE?

Answer: This is difficult to precisely predict recognizing that there are many competing needs external to the program, but we believe that if the current plan is carried out, sufficient scientific and engineering personnel resources will be available to proceed toward commercialization.

Question II: Your Magnetic Fusion Program has been focused to address the four key issues (magnetic confinement systems, properties of burning plasma, materials for fusion applications, and nuclear technology). How do you rank the Compact Alternate concepts in resolving the "confinement system" issue? (I don't mean compact Tokamak, but compact alternate). I still believe that Tokamak is much too large for a commercial system.

Answer: To resolve the magnetic confinement systems issue for fusion, a sufficient breadth of potentially attractive plasma and magnetic field configurations must be investigated and sufficiently understood to establish the base for economic fusion energy systems. Compact alternate concepts are being investigated because they have potentially attractive economic features and because their scientific diversity may lead to discoveries or insights regarding optimal magnetic confinement systems. Compact concepts currently being studied include the reversed field pinch (RFP), field reversed configuration (FRC), spheromak, and dense Z pinch. The above order is their approximate rank in terms of achieved performance and scientific understanding. If these concepts are ranked in terms of ability to influence or to benefit from improvements in other configurations, they would be ranked: RFP and/or spheromak, FRC and dense Z pinch. The RFP and spheromak share similar physics with each other, thus development of the RFP will automatically tell us more about the spheromak.

Ranking these concepts in terms of reactor attractiveness is difficult because of fundamental unknowns regarding how they would extrapolate to a working reactor. If we assume that our present understanding of each concept is basically correct, then the FRC has a definite advantage over the spheromak, which may rank slightly above the RFP in terms of reactor attractiveness. However, our present understanding is sufficiently meager to make it entirely possible that this ranking will prove to be incorrect. It is not possible to rank the dense Z pinch according to this criterion, because it is at such an early stage of development.

Question IIIa: In the MFE program, what priority do you place on the research staff compared to construction and support personnel, facilities, technology development, etc.? (It takes 5-10 years to put together a team of experts and such investment that cannot be easily replaced. Technology can be dealt with much easier.)

Answer: In order to do fusion research, one needs to provide support for all the above elements. It is impossible to say that one is more important than another, but rather, we must allocate our resources in such a way so as to have an appropriate balance among them. Obviously, if we were to allocate all our resources to fund research staff, without providing for facilities and support staff, then the tools required to do research would not be available.

Question IIIb: It seems to me that you have not provided sufficient funds in the Advanced Fusion Concepts (AFC) branch to retain core research staff while magnetic fusion projects are built in the Reverse Field Pinch (RFP) and (FRC) (Field Reverse Configuration) programs. Why were funds not provided to allow the staff to continue the needed AFC (Advance Fusion Concepts) research during the construction?

Answer: To develop magnetic confinement concepts we must progress though a series of experimental projects, each of which builds upon the knowledge gained from the previous ones. Failure to do this would lead to stagnation and loss of productivity.

Reductions in the magnetic fusion budget have made it very difficult to build new projects; and where projects have been undertaken, their funding has inevitably resulted in staff reductions somewhere in the program. Despite this difficulty, we felt that progress in the reversed field pinch and field reversed configuration programs warranted fabrication of new experiments that could extend plasma performance toward fusion conditions and could answer key physics questions. To partly pay the fabrication costs of these experiments the Advanced Fusion Concepts (AFC) budget was increased by 8% going from 1985 to our 1987 request even though the total magnetic fusion budget was reduced by 22% in the same period.

However, this increase is not enough to pay for all of the fabrication costs, and staff losses have occurred in AFC programs as well. We have tried to minimize the programmatic effects of these losses by cutting back lower priority research and by making special arrangements to retain key scientists. For example, scientists have moved temporarily from their home institution to work on other experiments, both in the U.S. and abroad.

Question IIIc: Why don't you just move the funds to where scientists are, instead of uprooting them?

Answer: Experimental scientists must have active experiments to work on if they are to be productive. During periods of shutdown, during fabrication, or after termination of an experiment, we are attempting to retain core research staff by requesting that they be re-assigned to ongoing experiments, usually at another institution. We are aware of the personal hardships that can result from these moves. We believe that this practice helps to retain individual scientific productivity and increases the effectiveness of fusion funding. So far, no one has been forced to move; people have volunteered. Such moves can also reduce fluctuations in overall fusion employment, because they provide skilled scientific manpower to experiments that might otherwise have to staff up. Finally, the cross fertilization of ideas can improve both the sending and receiving institution and the individuals involved.

Question IIId: You indicated that there are four large tokamaks in operation; what is the justification for the continued upgrades and operation while the alternatives have seemed so constrained?

Answer: There will be only two large conventional tokamaks in operation in the U.S. in FY 1987--the Tokamak Fusion Test Reactor (TFTR) at Princeton Plasma Physics Laboratory, and the D-III-D tokamak at GA Technologies. Each of these devices is unique and is optimized to address the basic tokamak scientific issues of fusion energy differently from the other. TFTR is designed to achieve a long-standing goal of the fusion program--the production of fusion power output equal to the plasma heating power input in a deuterium-tritium plasma. The present TFTR program plan is to achieve equivalent breakeven in a deuterium-deuterium plasma in 1987 and actual breakeven in a deuterium-tritium plasma in 1989. The objectives of D-III-D are to understand the physics of high temperature, high beta plasmas, and to study concepts that may substantially improve tokamak performance. The D-III-D device incorporates many of the tokamak improvements discovered during the past years of tokamak research including high plasma current, plasma elongation, and divertor capability.

Historically, the tokamak was the first magnetic configuration to demonstrate good confinement of high temperature, high density plasmas in devices of moderate size. As a result of continuous progress in tokamak performance over the past two decades, the tokamak remains far ahead of the alternatives in terms of plasma confinement efficiency. The promise of further advances in tokamak performance resulting in more compact, less expensive fusion reactors is sufficiently great to warrant continuation of a vigorous program of tokamak research.

At the same time, the support for alternative toroidal concepts has actually grown over the last several years, even in the face of declining budgets. These alternative toroidal concepts include the Princeton Beta Experiment (PBX) at Princeton Plasma Physics Laboratory, the Advanced Toroidal Facility (ATF) at Oak Ridge National Laboratory, and the Reversed Field Pinch (RFP) at Los Alamos.

The Princeton Beta Experiment is a tokamak with an advanced "bean" shaped cross section whose primary goal is to attain very high beta values in the second regime of plasma stability.

The ATF is a stellarator, which is an advanced toroidal configuration where the stabilizing magnetic fields are provided by external helical coils rather than a current in the plasma. The ATF is designed to study the fundamental principles of high beta, steady state operation in a unique toroidal geometry.

A new RFP began construction at Los Alamos in the FY 1986 budget year. This device relies upon intense ohmic heating at plasma currents of up to 4MA. It is expected to improve RFP confinement parameters a factor of three beyond existing devices and attain temperatures of 4kev.

Question IV: Let me get back to the core staff issue, what is the history of the number of core research Ph. D. staff at major laboratories over the past 10 years? (PPPL, ORNL, LANL, LLNL, MIT)

Answer: I would like to provide for the record a table which shows the number of Ph. D's supported at the major fusion laboratories in terms of FTE's since FY 1977.

(The information follows:)

Magnetic Fusion Support of Core Research Staff
(FTE's)

Fiscal Year	LANL	LLNL	PPPL	ORNL	MIT
1977	87	75	72	144	15
1978	82	75	101	124	16
1979	76	85	107	130	18
1980	76	87	110	139	23
1981	75	85	106	145	28
1982	68	84	114	145	33
1983	68	80	118	149	45
1984	67	83	119	136	44
1985	68	78	117	110	46
1986	60	70	115	108	49

Question IV a): From the facts gathered by my staff the core staff at LANL has dropped 41% since 1977, 27% since 1980 and again another 1/3 (30-50 people) in 1987.

What is your projection in FY 1987 if the President's budget is followed?

Answer: Estimates of Core Ph. D. staffing levels at major fusion laboratories for FY 1987 are 111 at Princeton Plasma Physics Laboratory, 108 at Oak Ridge National Laboratory, 63 at Lawrence Livermore National Laboratory, 52 at Los Alamos National Laboratory and 49 at Massachusetts Institute of Technology.

Question IVb: Granted all the labs would have to let people go with the budget crunch. But some labs have large staff to absorb large cuts. At LANL, the spheromak program will be terminated in FY87. Spheromak was appropriated $2.5 million in '85, $1.85 million in '86, and is zeroed in the FY87 request. How can we maintain a viable program? And what is the justification for terminating Spheromak?

Answer: The spheromak research program is planned to continue during FY 1987 with experiments at Princeton Plasma Physics Laboratory and the University of Maryland. Facilities at these institutions were specifically built to conduct the next phase of research. The CTX at LANL was chosen for termination because it is less suited for investigating the highest priority scientific questions than the other spheromak facilities. In addition the CTX was terminated because progress with that spheromak has been less successful than with the Field Reversed Configuration (FRC), which is the other variant of the compact toroid. In the context of the compact toroid program, the FRC therefore has a higher priority at present than the spheromak. The success of the FRC has led to the need for more advanced experiments, including new facilities at LANL for this approach. In view of overall fusion budget reductions, providing these facilities necessitated a cut back in spheromak funding. Experiments in Japan and theory development at several institutions will support these efforts and should enable us to maintain a viable program with reduced total funding.

Question VI: I understand the President again intends to mothball MFTF-B (Mirror Fusion Test Facility in LLNL) and House Appropriations has added $25 million to maintain the program.

- What is the mortgage of MFTF for?
  ($360 million)
- How much is required to finish the project?
  ($70-100 million)
- What is the annual operational cost?
  (1/5 of the Integrated Construction Cost = ($90 million)
- Your decision to mothball MFTF was based on both budgetary and technical considerations, was it not? Did MFAC (Magnetic Fusion Advisory Committee) panel of 16 recommend the mothballing of MFTF?
- Is it true MFAC said that before you operate MFTF, you need to prove the technical feasibility that both end-plugs would be able to keep high energy plasma (heat line) from leaking out?
- How does the mirror compare with the tokamak and alternate concepts in the area of achieving confinement parameters and reactor prospects?
- Do you plan to squeeze the portion of the mirror program that may continue into the present AFC budget to protect and even increase the tokamak budget?
- If $25 million is added with no strings attached, what is your priority? MFTF-B or other AFC such as Spheromak?

Answer: The House Appropriations Subcommittee did not suggest adding $25M to the MFTF-B program. In the Draft House 1987 Energy and Water Development Appropriations Report, they state "the recommendation provides for an increase of $25,000,000 above the request to restore a portion of the reductions (from the FY 1986 level). These funds are to be used to maintain mirror fusion research as a working alternative so as not to eliminate the primary competitor to Tokamak concepts. In addition, funds are added to maintain the schedule to achieve breakeven at TFTR in the 1988-1990 timeframe. In view of the restoration of funds for the mirror fusion program, the Committee expects that operating support for the Doublet III device be restored to 1986 levels in order to meet international commitments, and to

allow neutral beam and RF heating experiments to carry on as previously agreed to with the Japanese, and for the TARA device to provide data support for the MFTF-B. Finally, additional funds may be made available to university research initiatives to assist in maintaining a viable fusion program." It is clear that the House subcommittee added the funds into the areas of magnetic fusion energy where they felt the need was strongest. There are no plans to use these funds to operate MFTF-B.

As to the MFTF-B mortgage, the total cost of construction (construction and operating) would have been approximately $350M except that the operating funding has been stopped short of completion by approximately $70M. If completed, the annual MFTF-B operating cost would be approximately at least $70M a year in FY 1986 dollars.

The decision to mothball MFTF-B was based solely on budgetary considerations. In the absence of external budget pressures, the scale and pace of initial experiments on MFTF-B would have been guided by a technical evaluation of the progress on supporting experiments such as TARA and TMX-Upgrade. Previously, a technical decision had already been made to slow down the pace of MFTF-B experiments by beginning operation with 1/2-second pulses instead of 30-second pulses. The report of Mirror Fusion Advisory Committee (MFAC) Panel XVI supports the DOE decision to delay operation of MFTF-B.

With regard to the technical feasibility of the endplugs, MFAC has recommended that a focused mirror program "...should include definite milestones and decision points for continuation of mirror research beyond FY 1987. The thermal barrier must be successfully maintained with higher central cell densities ($10^{13} cm^{-3}$) and other meaningful target parameters." They also recommended that "The outcome of such a focused research program may be used as a basis for assessing the potential of MFTF-B."

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A subpanel of MFAC has been formed to further consider the technical goals of the mirror program. They will report to the full MFAC in late August.

The question of how mirror compares with the tokamak and alternate concepts, was addressed in the U.S. DOE report "Progress and Potential of Current Research Programs in Magnetic Fusion" submitted to Congress in February 1986. The report states "Mirror systems provide attractive design, assembly and maintenance features due to their linear configuration, and these features are expected to lead to a lower Cost of Electricity. All of the concepts have the potential to meet design goals for satisfactory safety and environmental characteristics. Tokamak, stellarator and tandem mirror concepts have the potential to achieve and exceed the value of 100 kWe/tonne for an economically attractive power reactor." The report also discusses the plasma confinement efficiency of all the concepts. The tokamak concept is close to an economically attractive reactor. The other leading concepts, including the tandem mirror, are factors of 10-20 behind the tokamak.

Any ongoing mirror program will be compared and contrasted with other alternate configurations, including the advanced toroidal program. We believe the present balance between the base tokamak and alternate concept activities is appropriate.

If an amount of $25M were added with no strings attached, we would still support the priorities cited in the report drafted by the House Appropriations Committee. This report accurately represents the critical needs of the Fusion program.

ACNP 1101 Connecticut Avenue, N.W. • Suite 700 • Washington, D.C. 20036 SNM
American College of Nuclear Physicians
202-429-5120
The Society of Nuclear Medicine

July 11, 1986

The Honorable Pete V. Domenici
Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
SD-317 Dirksen Senate Office Building
Washington, DC 20510

Dear Senator Domenici:

Howard Dworkin, M.D. has asked me to send you the enclosed responses to the questions you sent him, to be included in the record of the hearing on the Department of Energy's FY 1987 Budget Authority June 23.

Dr. Dworkin, as well as all members of the Society and College, appreciates the interest of your committee in the advances now being made in Nuclear Medicine research under funding from the Department of Energy.

As these answers to your follow-up questions bring out, DOE support of Nuclear Medicine research has provided the basis of virtually all current clinical practice, and the research currently underway under DOE has opened a number of opportunities for advances which will contribute greatly to health care.

Sincerely,

Robert H. Wilbur
Director - Government Relations

RHW/st
Enclosure
cc: Marilyn Meigs

QUESTIONS FOR DR. HOWARD DWORKIN

THE SOCIETY OF NUCLEAR MEDICINE

Q1: What would you say are the most valuable applications of Nuclear Medicine in present-day clinical practice which have resulted from DOE nuclear medicine research in the past?

A: DOE Nuclear Medicine research was the basis of the two major applications of Nuclear Medicine in clinical practice today: the molybdenum-99 generator which produces the radionuclide used in 80% of modern Nuclear Medicine scans (developed at Brookhaven National Lab supported by the predecessor of DOE) and the imaging device most used in Nuclear Medicine today, the Anger camera (developed at Berkeley National Lab under the same funding mechanism). In more recent years, gallium-67, introduced for tumor and abscess scanning, and thallium-201, for cardiac imaging, have been developed under DOE. Both of these isotopes are accelerator-produced and involve high-technology. Several iodine-123 compounds which are becoming more and more important in the assessment of cerebral blood flow were also assisted by DOE.

It is no exaggeration to say that virtually all of the approximately 6.5 million Nuclear Medicine imaging and therapeutic procedures performed annually at the 4,500 U.S. facilities licensed by the NRC in Nuclear Medicine are based on technologies which would not have existed without research supported by DOE and AEC.

Q2: A number of DOE research projects are for further research and refinement of Positron Emission Tomography. What are the clinical uses likely to emerge from this research?

A: To date, the studies in positron emission tomography have been very useful in understanding basic physiological mechanisms in the normal and diseased states in both the brain and the heart. Clinical uses of PET now emerging permit us to diagnose disease, quantify the degree of abnormality, decide on appropriate therapy in such areas as epilepsy, stroke, dementia, and coronary artery disease, far better than before. Recent advances supported by DOE in the diagnosis and evaluation of brain and breast tumors and their metastases using receptor based radiopharmaceuticals have immense promise for the noninvasive diagnosis and evaluation of estrogen receptor containing tumors and metastases.

Q3: I understand that the development of monoclonal antibodies is one of the most promising areas of research into diagnosis and treatment of cancer. Is DOE doing enough to support this in its Nuclear Medicine research program?

A: In an isolated laboratory setting, the labeled monoclonal antibodies techniques work quite well. However, there is a need for research to understand the difficulties that are encountered when

labeled monoclonal antibodies are injected intravenously, since under these conditions they attach to many different processes within the body and are rapidly broken down with the end result that the tumor to tissue ratios are relatively poor for imaging or selected therapeutic applications. It would appear that there is a need for a fundamental breakthrough in the field of monoclonal antibodies from the basic sciences. Until this happens, I am not sure that we are going to see much progress in our Nuclear Medicine research program to overcome the confounding problems that face monoclonal antibody approaches in the in-vivo setting. DOE is supporting work at Brookhaven National Lab, Los Alamos National Lab, University of California, Davis, Washington University, St. Louis, George Washington University, and others in this important area.

Q4: Are the appropriations requested this year for the Nuclear Medicine research program sufficient to make the most of the research opportunities available and to maintain the DOE laboratories supporting research in Nuclear Medicine? Is there a danger that we will fall behind by underfunding maintenance at DOE laboratories?

A: A large number of the laboratories supported by DOE require large pieces of equipment that need maintaining and replacing. With the current level of support there is a serious probability that important pieces of equipment will fall into disrepair. One prime example of this are the Calutrons at Oak Ridge National Lab which are necessary to produce the enriched targets needed for many of the isotopes prepared in Nuclear Medicine today. Without additional funding in this area there will be serious problems.

During the last 10 years and particularly during the last six years, the budget has been flat or decreasing, after adjustment for inflation. This has meant a progressive decline in support. In addition, the Nuclear Medicine programs in Europe and particularly Japan are on the upswing with significant, rapid technical advances. For example, Japan has made a national commitment to PET and is funding six large companies (Hitachi, Homomatsu, Shamazu, Japan steel works, Sumotomo) and 12 universities and institutes. The rate of advancement in the last 3 years in Japan is most impressive.

Q5: How does DOE maintain contact with the Nuclear Medicine research community in establishing priorities and evaluating research proposals?

A: DOE maintains its contact by DOE staff people attending general Nuclear Medicine meetings, visiting the DOE Nuclear Medicine laboratories, sponsoring special topic oriented meetings and by personal contacts with leaders in the field. They also use

the peer review system for evaluating proposals. This generally seems to work reasonably well, although I think there should be more personal contact between the DOE staff members and the investigators in the DOE research labs, as well as with leading scientific investigators throughout the Nuclear Medicine community.

In this era of cost-consciousness, close communication between the DOE and the Nuclear Medicine research community becomes even more important. A task force on radiopharmaceuticals consisting of representatives of the American College of Radiology, the Society of Nuclear Medicine, and the American College of Nuclear Physicians recently produced a series of recommendations; one of which was "a new DOE committee should be established at the level of the Office of the Assistant Secretary for Energy Research to advise the Secretary on important new directions for future research projects in diagnostic imaging and therapy. Although this committee would be appointed by the DOE, it is hoped that the DOE would ask for nominations from the organizations forming the Intersociety Radiopharmaceutical Development Task Force. The objective of this advisory committee would be based in part on a needs analysis for new directions in research and also on evaluation of past and present government-sponsored research projects within the Department of Energy." We believe that this recommendation from the task force report suggests a new and improved method for DOE contact.

Q6: Is the Nuclear Medicine community aware of the potential capabilities at the Power Burst Facility at the Idaho National Laboratory for pursuing cancer research in boron neutron capture technology? What promise does this research hold for advancements in cancer treatment?

A: The Nuclear Medicine community is aware of cancer research in boron neutron capture technology. Although boron neutron capture technology has potential there is an enormous problem in directing sufficient quantities of boron into the tumor. Current work being carried out at Ohio State University by Prof. A. H. Soloway supported by the DOE in chemoradiotherapy of cancer using boronated monoclonal antibodies and other boron compounds is addressing this very difficult problem.

Q7: The House Appropriations Committee has cut $5 million in Nuclear Medicine research. What would be the impact of such cut?

A: The House Appropriations Subcommittee on Energy and Water Development has recommended a $5.5 million cut from the $196.6 million requested by DOE for Biological and Environmental Research. The recommended appropriation of $191.5 million

represents a slight increase from the FY 1986 appropriations for these programs of $187.7 million (and from the adjusted budget authority of $179.9 million). The House Subcommittee has not yet made recommendations as to the funding levels for the individual programs, such as Nuclear Medicine, which are part of this overall budget.

The House Subcommittee on Natural Resources, Agriculture Research, and Environment has recommended an appropriation for Nuclear Medicine research for FY 1987 of $23.3 million, an increase of $1.2 million over the DOE request. While this is below optimal levels, it would permit the continuation of research at approximately current levels.

Obviously, a cut of $5.5 million if made against Nuclear Medicine research would be catastrophic. Even smaller cuts would require termination of funding for several of the major research projects outlined above, slowing for years, perhaps for a generation, the development and introduction of advances in Nuclear Medicine which show great promise for improving the health care of our country.

Q8: What is the optimal funding level for Nuclear Medicine Research? And what research areas should be emphasized?

A: It is difficult to recommend an optimal level for Nuclear Medicine research, as the limited current availability of research funds discourages initiatives, slowing the opening of new pathways which would appear if additional funding should become available.

We believe it is essential, as recommended by the House Subcommittee on Natural Resources, Agriculture Research, and Environment of the House Committee on Science and Technology, that funding for FY 1987 be no less than the adjusted appropriation for FY 1986 of $23.3 million; progress in Nuclear Medicine would clearly be accelerated, while maintaining extremely high levels of cost effectiveness, at levels closer to $30 million for FY 1987.

Looking further ahead, we would recommend that funding for Nuclear Medicine research should be doubled within the next five years. Staging this increase over that period would ensure that DOE, unable to fund all worthwhile proposals, would be able to fund only the most promising, therefore assuring the highest level of cost-effectiveness for those selected.

Q9: What research facilities are not being maintained due to insufficient funding?

A: It is probably true that none of the DOE Nuclear Medicine research facilities are maintained adequately. The DOE Nuclear Medicine labs at UCLA, Donner labs at Berkeley, and Brookhaven lab are all clearly not being maintained due to insufficient DOE funding. This declining trend must be turned around to reestablish a strong sense of union and commitment between the university-based programs and DOE.

DOE has been the principal origin of the technology, methodology and procedural development that lie at the basis of clinical Nuclear Medicine. Considering the level of support to Nuclear Medicine within DOE, there has been an amazing efficiency in innovation and technology leadership. Base technology developed throughout the greater DOE program is continually transferred to the DOE Nuclear Medicine programs where various technology approaches are investigated, refined, validated and transferred to clinical research and then to clinical practice.

The development of the cyclotron, rectilinear scanners, gamma cameras, isotopes, labeled compounds, and tracer kinetic methods have been used throughout the history of the DOE Nuclear Medicine program to develop new knowledge and understanding about the basic mechanisms of disease and normal functions of the body and to yield in-vitro and in-vivo radioassays that have made major contributions to the health and care of the American people. These developments have been expanded to the care of people throughout the world through the leadership that exists in this country.

Even the newest technology of positron emission tomography (PET) originated and has grown up within the technology transfers and support of DOE. This stands once again as another innovative approach originating from DOE with great hope and promise for new contributions to medical research and care. Such basic technology developments are not covered in the normal scope of the National Institutes of Health and DOE has, therefore, provided a unique and successful continuing contribution. Once these basic technology developments occur, shared funding and transfer of support from NIH occurs, but because of the unique nature of Nuclear Medicine, the beginning is with DOE.

APPENDIX VII

Additional Material Submitted for the Record

American Chemical Society

DEPARTMENT OF GOVERNMENT RELATIONS
AND SCIENCE POLICY
LEGISLATIVE PROGRAMS

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4466

June 18, 1986

Ms. Marilyn Meigs
Subcommittee on Energy Research
and Development
Committee on Energy and Natural Resources
U.S. Senate
Washington, D.C. 20510

Dear Ms. Meigs:

The enclosed American Chemical Society (ACS) statement is being submitted for the record of the hearing to be conducted on June 23, 1986, by Senator Domenici's Subcommittee on Energy Research and Development. The subject of this hearing is the FY 1987 DOE Budget for Basic Energy Research.

Please call me if you have any questions concerning the ACS statement. Thank you for your consideration.

Sincerely,

Anna Fotias

Anna Fotias
Manager

Enclosure

American Chemical Society

OFFICE OF THE
PRESIDENT

George C. Pimentel
President-Elect, 1985
President, 1986
Immediate Past President, 1987

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4600

June 23, 1986

The Honorable Pete V. Domenici
Chairman
Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

The American Chemical Society appreciates this opportunity to present its views on the Department of Energy's FY 1987 budget request and to comment upon specific support for research in the chemical sciences under programs of the Office of Energy Research. Specifically, the ACS believes that:

> The appropriate areas of Basic Energy Sciences programs should receive an additional $22 million in FY 1987 for research in reaction kinetics, catalysis, and plant sciences. The Department of Energy must invest more heavily in research that explores the energy-related frontiers of chemistry where there is great potential for contributions to DOE's mission.

The long-term needs of the United States indicate that, as a Nation, we cannot ignore the energy area. Recently, Dr. Edward E. David, Jr., retired President of Exxon Research and Engineering Company, said that, "In energy, as elsewhere, new knowledge is both a critical and a renewable resource. Will the world develop the necessary knowledge in time to avert the next energy crisis? One thing we do know is that remarkable opportunities are emerging in the relevant areas of fundamental chemical science."(1)

This view is persuasively reinforced in the following excerpt from the National Academy of Sciences/National Research Council (NAS/NRC) Report, Opportunities in Chemistry:

> Every proposed scenario for energy consumption over the next four decades projects the need to optimize access to every energy source at our disposal. This need is made more urgent as we face the inevitable depletion of liquid fossil fuels because there will also be stiffening constraints imposed by the desire to

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1. Edward E. David, Jr., "Chemistry and The Next Energy Crisis," The Chemist, January 1986, p. 6.

protect the environment. In this setting, chemistry will continue to be the central scientific discipline in meeting the nation's energy requirements.(2)

The Report highlights the fact that over 90 percent of our energy consumption is based on chemical technology, yet the Department of Energy devotes only a modest fraction of its fundamental research program to the chemical sciences. In FY 1985 for example, the eleven fundamental research programs under the Office of Energy Research (Appendix I) received a $1.4 billion DOE commitment. Within this budget, the Chemical Sciences program, which funds mostly chemical research, is $79.5 million, less than 6 percent of the total. The Biological Energy Research program is $12.5 million, less than 1.0 percent of the total. Of course other programs contain chemistry components. For example, the Materials Sciences program devotes $33.7 million of its budget to chemical research. This amounts to 2.4 percent of the total fundamental research budget.

The last column of Appendix I indicates the results of identifying every program element that might be labelled chemical research. When contributions to "chemical sciences" are extracted from these fundamental research programs, they amount to approximately $175 million, or 12 percent of the total figure of $1.4 billion.

With chemical technology providing over 90 percent of the energy consumed in the United States, a trend which will undoubtedly continue for the next three decades, 12 percent of the fundamental research budget is an inadequate investment, especially when it is recognized that chemistry is no longer a "test tube" science. Greater resources are required to provide for the increasingly sophisticated research instrumentation and the increased cost of the support structure needed to carry out high quality research.

In order to meet the enormous challenges posed by new and lower quality energy sources, and at the same time to decrease the environmental impact of energy use (acid rain, smog, etc.), the U.S. must develop new catalysts, processes, fuels, and extraction techniques; more efficient combustion conditions; a better understanding of the fate of emissions; better emissions controls; and more sensitive environmental monitoring techniques. As a result, the Department of Energy must invest more heavily in the relevant frontiers of chemistry. These frontiers are clearly delineated in the Report, Opportunities in Chemistry, which indicates the many ways that the chemical sciences are ready to meet future challenges, if adequately funded.

As a first step towards meeting these needs, the American Chemical Society endorses the recommendation of the NAS/NRC Report that $22 million be added in the appropriate areas of the Basic Energy Sciences programs to support reaction kinetics, catalysis, and the plant sciences.

Reaction Kinetics - The amazing potential of lasers and computers for understanding the entire course of a chemical reaction needs to be exploited. Such an understanding could lead to better combustion efficiencies. An increase

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2. National Research Council, Opportunities in Chemistry (Washington, D.C.: National Academy Press, 1985), p. 34.

in combustion efficiency would be worth billions per year to the U.S. economy. Of course, a further important bonus could be the reduction of smog and acid rain.

Catalysis - The full range of sophisticated instrumentation techniques should be brought to bear on the crucial area of catalysis. These techniques extend across the range of homogeneous, heterogeneous, electro-, photo-, and enzymatic catalysis. Advances in catalysis could lead to more efficient production and use of energy sources.

Plant Sciences - The use of natural and artificial photosynthesis, biomass, and genetic engineering of photosynthetic organisms should be facilitated to capture and utilize solar energy in better ways.

Increased support and resources must be committed by the Depa-tment of Energy to these frontier areas over a sustained period of time. The NAS/NRC Report provides a five-year plan for such support (Appendix II). This plan, if followed, would result in an incremental growth of about 2.5 times the chemical research funding, which was available for these areas under the Basic Energy Sciences programs in FY 1985. The Energy Research Advisory Board's Chemistry Ad Hoc Review Panel, in its draft February 1986 report, has endorsed this recommended growth, which is equal to $33 million per year in FY 1985 dollars.

The American Chemical Society supports the increases proposed in the operating budgets of the Chemical Sciences program and the Biological Energy Research program. The Society believes, however, that a larger increase is warranted and could be used effectively. The stakes are too high and the potential benefits to our economy are too significant to postpone adequate funding of these important initiatives.

The Society recognizes that FY 1987 is a year in which budget restraints are being demanded. These times of economic stress are times of difficult priority choices; it is a time for retreat in some areas, and a time for increased investment in areas that will guarantee future progress. Japan and Great Britain have already identified and intend to provide additional support to these same energy-related research areas.(3)(4) A number of U.S. scientific programs that involve much larger expenditures are under consideration. They show that the cost of the initiatives detailed in our statement would be modest investments, but ones directly relevant to the DOE mission.

In closing, the ACS supports a competitive, merit-based peer-review process as the primary mechanism for selection of research and instrumentation proposals for large-scale centers and facilities. The Conference Report on HUD-Independent Agencies Appropriations (H.Rpt.99-363) endorsed such a principle. It is hoped that this Subcommittee will issue a similar statement of support.

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3. "Recommendation of the Council for Science and Technology on the 11th Inquiry titled, 'Comprehensive Fundamental Policy for Promotion of Science and Technology to Focus Current Changing Situations from the Long-term View,'" The Council for Science and Technology, Japan, November 1984.

4. "Bread and SERCuses," John Albery, Chemistry in Britain, May 1984, p. 413.

The ACS appreciates the opportunity to express its views. The Society believes that the costs of its recommendations are minimal compared to the many potential benefits derived in helping to insure a stable, long-range energy supply in the U.S. and in reducing the Nation's vulnerability to the uncertainties of foreign oil supplies.

Sincerely yours,

George C. Pimentel

Appendices (2)

cc: Other Members, Senate Energy and Natural Resources
Subcommittee on Energy Research and Development

APPENDIX I

Relative Funding of Chemical Sciences Among Ten DOE Fundamental Research Programs

(operating expenses - dollars millions)

Office of Energy Research Programs	1985 Enacted (a)	Chemical Sciences Portion (b)
Fusion	$ 374.3	$ 0
High Energy Physics**	372.9	0
Biological and Environmental Research	176.1	33.7
Nuclear Physics **	146.9	7.3-14.7 (c)
Materials Sciences *	133.1	33.7
Chemical Sciences *	79.5	68.8
Nuclear Sciences *	40.4	12.2
Applied Mathematics *	35.1	0.6 (c)
Engineering and Geosciences *	26.7	5.3
Biological Energy Research *	12.5	9.8
Advanced Energy Projects *	10.6	1.3
TOTAL	$1,408.1	$171.7-179.1

* Programs funded under Basic Energy Sciences
** Programs funded under General Science and Research

a) Source: Senate Report 99-110, "Energy and Water Development Appropriation"
b) Source: DOE provided for Energy Research Advisory Board's Ad Hoc Chemistry Review Panel, January 1986. Chemical Sciences portion may contain chemistry, biochemistry, and chemical engineering. Figures may include share of operating expenses at national laboratories.
c) DOE: very rough estimate.